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ORIGINAL ARTICLES.

I.—Eminent Living Geologists, No. 9: Dr. G. M. Dawson, C.M.G., LL.D., A.R.S.M., F.R.S., F.G.S., F.R.S.C., etc., Director of the Geological Survey of Canada.

(WITH A PORTRAIT, PLATE VII.)

DR. GEORGE MERCER DAWSON, F.R.S., whose portrait we present to our readers this month, is the son of Sir William Dawson, F.R.S., for many years Principal of McGill College, Montreal. Dr. Dawson was born at Pictou, Nova Scotia, August 2, 1849, and his early years were passed in Canada. After continuing his education in Scotland, he obtained his special training for a scientific career in the Royal School of Mines, Jermyn Street, of which he is an "Associate," and where he was also awarded the "Murchison" and "Edward Forbes" Medals. His first scientific appointment was as Geologist and Botanist to the British North American Boundary Commission, which in the seasons of 1873–4 marked out the International Boundary between the United States and the Dominion of Canada, for a distance of 800 miles in length, from the Lake of the Woods to the Rocky Mountains. Dr. Dawson devoted his observations more especially to the geology of the region traversed by the Commission, a large part of which was, at the time, quite unknown; and he gave an admirably succinct account of this and other features of the country, in his Report on the Geology and Resources of the Region in the vicinity of the forty-ninth parallel, published in 1875. This work clearly proved his capability as a field geologist, and in the same year he was appointed to the Geological Survey of Canada, with which he has since been connected, first as Assistant-Director under Dr. A. R. C. Selwyn, F.R.S., and afterwards as Director, on the retirement of Dr. Selwyn in 1894.

Dr. Dawson's geological work has been mainly carried on in the North-West Territories of the Dominion and in British Columbia. For many successive years he has been engaged in field-work in these wild and unsettled regions, where geological investigation is necessarily of a very arduous character, and much physical energy and endurance are required to cope with its hardships. In the course of his explorations, Dr. Dawson has visited such outlying regions as the Queen Charlotte Islands (1878), the northern part of

British Columbia and Peace River (1879), and the Yukon district (1887). Our present knowledge of the geology of these districts is largely from the observations carried out by Dawson and published in the voluminous Annual Reports of the Survey. Even in British Columbia, apart from the preliminary reconnaissance of Dr. Selwyn in 1871 and the work of the late Mr. J. Richardson on the Cretaceous strata of the coast areas, we are almost entirely indebted to Dr. Dawson for establishing the taxonomic relations of the rocks.

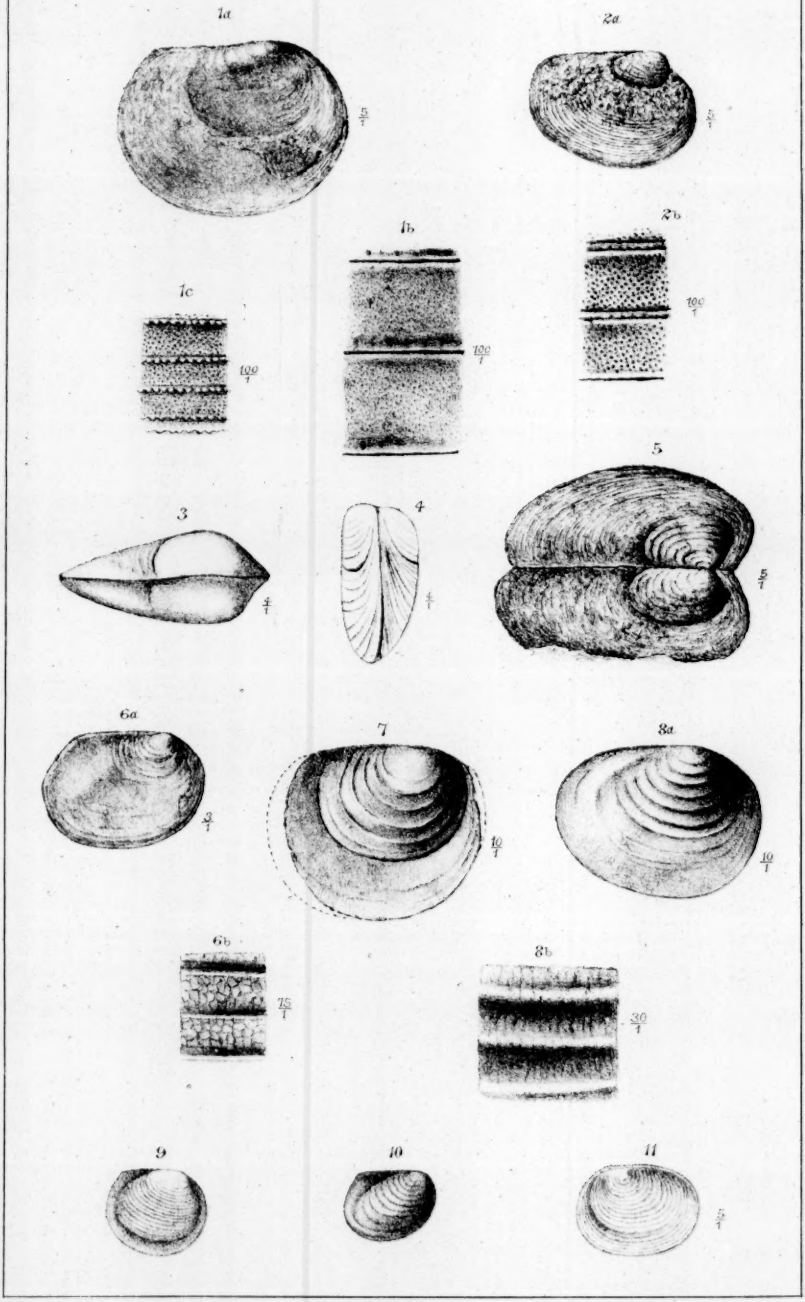
On the great plains of the North-West, Dr. Dawson has investigated more particularly the relations of the Cretaceous and the Laramie formations; and he has discovered the presence in the first-named formation in Southern Alberta of an important series of fresh-water rocks, the Belly-river group, which has not been noticed in the section of the Cretaceous worked out by Meek and Hayden on the Upper Missouri. In the adjacent Rocky Mountain region, another distinct group, the Kootanie, has been likewise recognized by Dr. Dawson as representing a period in the early Cretaceous.

Amongst the more ancient rocks of Canada, Dr. Dawson has ascertained that a great part of the Huronian formation in the Lake of the Woods district is composed of metamorphosed volcanic rocks. In British Columbia also, after a detailed examination of over 6,000 square miles of the interior plateau region, he has made known the existence of a thick series of mica schists and gneisses of presumed Archæan age, which are succeeded by Cambrian, Ordovician, Silurian, and Carboniferous strata. In the Cordilleran region of this province, he has further noted the occurrence of great deposits of contemporaneous volcanic rocks, in various stages of metamorphism.

At the other end of the geological scale Dr. Dawson has largely contributed to our knowledge of the glacial phenomena which in Canada are so strikingly developed. He was the first to describe the glacial origin of the Missouri Couteau; and in the interior plateau of British Columbia he has shown that at one period of the Ice Age, there was a confluent ice-mass the surface of which stood at a level of 7,000 feet above the sea, and that it must have been at least from 2,000 to 3,000 feet in thickness. He has further established the fact that the movements of the glacier ice in this region were not only to the south and south-east, and through the transverse valley and gaps of the coast-ranges to the ocean, but that it had also a northerly flow, and passed down the valleys of the Pelly and Lewes branches of the Yukon river.

With regard to the glaciation of the northern part of the Great Plains, Dr. Dawson maintains that the region, as a whole, has been submerged, and that floating ice has been the main agent in its glaciation, a view which is not in accord with that of the majority of American geologists.

Besides in the Canadian Survey Reports, Dr. Dawson's observations on this and other branches of geology, have appeared in the



T. Rupert Jones direxit. Geo. West & Sons lith. et imp.

ESTHERIÏNA.

Quarterly Journal of the Geological Society, The Geological Society, the Transactions of the Royal Society of Canada, the Journal of Geology (Chicago), and in other American publications.

But Dr. Dawson's services to Science and the State have not been limited to Geology, for in 1891 he was appointed one of H. M. Behring Sea Commissioners, and made an extended cruise in that sea, investigating matters relating to the life and history of the fur-seal. He made use also of the opportunity to observe some interesting geological facts on the coasts and islands passed by, which were afterwards published in the Bulletin of the Geological Society of America (1894). Afterwards Dr. Dawson took part, as one of the Commissioners, in the Conferences held at Washington, and he subsequently assisted in the preparation of the British Case which was laid before the Behring Sea Arbitration Commission at Paris.

The value of Dr. Dawson's work has been duly recognized by geologists in this country as well as in Canada. The Geological Society of London awarded to him the Bigsby Medal in 1891, and in the same year he was elected a Fellow of the Royal Society. For his services on the Behring Sea Commission he also received the title of C.M.G. He served as President of the Royal Society of Canada in 1894, and his Presidential Address for that year embodies a careful review of what has been done, and what should be attempted, in the various branches of science in Canada. We are glad also to state that Dr. Dawson is to be the recipient this year of a gold medal from the Royal Geographical Society, a well-deserved honour.

The Geological Survey of Canada is fortunate in having so able a geologist as Dr. Dawson for its Director. In advancing our knowledge of the geology of that vast region and thereby contributing to its economic prosperity and development, Dr. Dawson will, we are confident, successfully carry forward the work of his eminent predecessors Logan and Selwyn. G. J. Hinde.[1]

II.—On some Fossil Entomostraca from Brazil.

By Professor T. Rupert Jones, F.R.S., F.G.S.

(PLATE VIII.)

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§ I. Introduction.

A collection of about twenty specimens of three or four kinds of shales, bearing several Estherian and small Molluscan fossils, was made by Mr. Joseph Mawson, F.G.S., Superintendent of the Bahia

[1] Assisted by notes kindly supplied by J. F. Whiteaves, F.G.S.

and San Francisco Railroad, several years ago, and presented by him to the British Museum. These are marked with the distances, in kilometres, from Bahia on the railway; and are provisionally referred by Mr. Mawson, some to the "Cretaceous" and some to the "Wealden" series. None are especially characteristic of these formations; but the strata containing them have been referred by Mr. C. F. Hartt to his "Bahian" Group of the Lower Cretaceous; equivalent, he thought, to the Neocomian of Europe. Mr. Hartt was one of the members of the Thayer Expedition, under Louis Agassiz, and published in his "Geology and Geography of Brazil" (1870) the details of his observations made along the railroad from Bahia to Alagoinhas on the San Francisco River (see pp. 349–372, and 555, 556).

These more or less fossiliferous beds rest on gneiss; and there are some overlying Tertiaries (?) at the eastern end of the Pojuca tunnel (p. 371).

Mr. Hartt's small sketch-map at p. 286 shows the bay, the town, and the railway. The last passes north-eastwardly from Bahia to Moritiba on the Rio Joannes; and thence northward to Matto de São Joăn, Pitanga, Pojuca, and Alagoinhas.

Dr. A. C. White, in his "Cretaceous Invertebrate Fossils" of Brazil, 1888, has described and figured many of the fossils collected by the Expedition under L. Agassiz, and in Mr. Mawson's collection there are a few of such as Dr. White treats of, but not from the same locality.

Mr. Hartt refers in a few instances to the occurrence of *Estheriæ*: thus, at p. 349, referring to a group of shales, some black and laminated, and some lighter in colour, micaceous, and not well laminated, at Pedra Furada, not far from Monserrat, he says: "In this shale are to be found layers abounding in Entomostracan remains, of which the most interesting is an Estherian,[1] with its valves marked with concentric ridges, like an Astarte, and apparently new." Fish-remains are present. This shale at Pedra Furada is associated with a fossiliferous limestone, shales, sandstone, and conglomerate; continuous with the fossiliferous series, described by Allport,[2] at the Fort of Monserrat, Bahia.

Plantaforma, two miles from Monserrat, in a north-east direction (p. 347), is a hill of the same formation as that at Monserrat, and the same beds are exposed all the way from Plantaforma to the little bay of Periperí, about half a mile from Plantaforma; and where the railroad passes close to the water's edge (p. 354) there is exposed a section,[3] about 10 feet high, of shales and conglomerates, overlying a bone-bed and shales. Reptilian and fish-remains abound in the bone-bed (American Journ. Sci. and Arts, vol. xlviii, May, 1869).

Just below the station at Pitanga are shales and sandstones (section given at p. 368); in one shale, "C," is an Estherian like

[1] Probably the *Estheriina Bresiliensis*, described further on.

[2] Quart. Journ. Geol. Soc., vol. xvi, 1860, pp. 263–8.

[3] *Estheria Mawsoni*, sp. nov. (to be described shortly), and some small Lamellibranchs appear to belong to this section, at kilometres 12–13 from Bahia.

that at Pojuca tunnel, which traverses "Cretaceous" strata near Tertiary hills (view given at p. 371). In the cutting at the eastern entrance of the tunnel horizontal Tertiary (?) beds of soft brown sandstone occur, and in them "a bed, fifteen centimètres in thickness, of a yellow clay, decomposed shale (?), in which I have found a few Estherians"[1] (p. 371). The laminated blue-grey sandstone of the tunnel contained fish-remains and fragments of plants.

Summary of the occurrences of Fossil *Entomostraca*, etc., collected by Joseph Mawson, Esq., F.G.S., from cuttings on the Bahia and San Francisco Railroad, Brazil, 1888.

	At Kilometres from Bahia.							Brit. Mus. Nos.
Estheriina Bresiliensis, gen. et sp. nov.	3·85, 4, 5	—	—	—	—	—	—	13, 37, 371, 372.
——— *expansa* ,,	—	—	—	—	—	83	—	L. 304·4.
——— *astartoides* ,,	—	—	—	—	—	83	—	L. 304·3, L. 304·4, L. 304·5.
Estheria Mawsoni,[2] sp. nov.	—	12–13	73	74	82	83	—	No. 31, L. 304, L. 304, L. 304·1,
——— ——— var.[2]	—	12–13	73	—	—	—	84·5	L. 304·2, L. 304·4, I. 466, I. 466, 6–10.
Cyprididæ[2]	—	—	—	—	—	83	—	L. 304·3.
Anodonta Harttii, White ...	—							
——— *Mawsoni*, White ...	—	12–13	—	—	—	—	—	L. 304.
——— sp.	—							
Area, sp.	—							

§ II. Estheriïna, genus novum.

An Estherian carapace, the valves of which are not equally gibbose throughout, but more convex for a limited area in the umbonal region than lower down in the ventral region. Lines of growth are strongly marked on the convex portion; and are feeble, but numerous, on the flat marginal area, which varies in expansion in different species.

Three forms are observed in the Brazilian series under notice; and two published fossil forms seem to come into the same genus.

The zoological value of the umbonal convexity may be differently estimated from different points of view. It certainly seems to represent an exuberant growth of the early, compared with the later, parts of the animal and its valves. Although neither the "protoconch" in Gasteropoda and Cephalopoda, nor the "prodissoconch" in Lamellibranchiata, constitutes a classificatory feature in their genera or even their species, yet the persistent enlargement of the early part of the valves in bivalved Estherian Entomostraca is peculiar, and may be conveniently recognized as distinctive of a genus, or at least of a subgenus, in this group of Phyllopoda.

[1] It is probable that *E. Mawsoni* (to be described subsequently) was seen by Mr. Hartt at Pitanga and Pojuca.

[2] To be described in another communication.

§ III. 1, Estheriïna Bresiliensis, gen. et sp. nov.

PLATE VIII, Figs. 1*a–c*, 2*a*, *b*, 3, 4, 5.

Valves subovate, with the earliest (umbonal) part of the valve very much more convex than the other part of the surface, and looking like an exaggerated growth of what had been prodissoconchal.[1] This neanic portion differs somewhat in colour, and probably in intimate structure to some extent. The outline of different specimens varies according to their stages of growth and sexual form; also by their having been subjected to pressure during fossilization. On the limited umbonal convexity, the lines of growth are marked by eight or nine concentric ridges, relatively coarse, and wide apart; whilst on the lower and outer, expanded, flatter, newer part of the valve the ridges of the lines of growth are thinner, much closer together (thirty or more), and neatly beaded with projections, probably the modified bases of earlier setæ. Near the edge of the valve this ornament becomes a mere crenulation on the close-set concentric ridgelets (Fig. 1*c*).

The interstitial ornament consists of a delicate and crowded pitting (Figs. 1*b*, 1*c*).

The valves are black, thin, and apparently chitinous, sometimes glossy on the boss or umbonal swelling; which, therefore, seems to be somewhat different in constitution; moreover, in some individuals it is of a brownish tint.

Fig. 1, a right-hand valve, much flattened and otherwise modified, is relatively the shortest and highest of the best specimens. It has a broad and blunt oval outline. In dark-coloured greenish-black fissile shale, with ferruginous staining on some bed-planes; some lam næ are sub-bituminous; some faces glazed and slickensided. With fish-remains.

Size.—Valve, length 6·4 mm., height 5 mm.; umbonal convexity, length 3·6 mm., height 2·4 mm. From a cutting on the Bahia and San Francisco Railroad at kilometre 5 from Bahia, near the viaduct.

Fig. 2, slightly crushed, has a subovate outline, much narrower posteriorly than Fig. 1. From the same dark shale, with fish-remains, at kilometre 4 on the railroad.

Size.—Valve, length 5·6 mm., height 3·2 mm.; umbonal convexity, length 1·6 mm., height 1 mm.

Besides this perfect valve there are on the same slab several imperfect valves and a pair in position, but not perfect; also three separate umbonal bosses, one of them shiny.

Figs. 1 and 2, differing by either variety, sex, or stage of growth, appear to represent the normal form.

Figs. 3 and 4 represent the edge view and the end view of the carapace, somewhat diagrammatically.

Fig. 5, from the same dark shale, a little nearer to Bahia (at 3·85 kilom. on the railroad), "near the junction of the Cretaceous with the Gneiss," shows two valves in apposition, umbo to umbo, opened

[1] The prodissoconch is more or less persistent in some bivalved Molluscs, as *Sphærium*, *Pisidium*, *Ostrea*, *Avicula*, etc.

out under pressure, but not to the fullest extent. In their height, modified by squeeze, these valves are much less than that of Fig. 1.

Size.—Valve, length 7 mm., height 2·6 mm.; umbonal convexity, length 2·8 mm., height 1·4 mm.

There are several other specimens of these black and shining valves of approximately similar shapes, but more or less altered by pressure, both scattered on the dark-coloured shale from "kilom. 4," and lying thickly together in the dark and almost bituminous shale from "kilom. 5."

Remarks on some Allied Forms.—A somewhat similar feature (namely, the umbonal convexity) occurs in H. B. Geinitz's "*Estheria Freysteini*," from the Coal-measures of Saxony. A large portion of the valve is raised in a persistent convexity near the umbo (10 mm. long and 8 mm. high, in a valve 12 × 10 mm.), leaving a flattened marginal area, much narrower than in the Brazilian specimens under notice. There is also some indication of this characteristic feature in Goldenberg's "*Estheria limbata*." For the purpose of comparison, concise descriptions of these two forms are here given.

§ IV. 2, Estheriïna Freysteini (Geinitz), 1855 and 1876.

PLATE VIII, Figs. 9, 10.

Cardinia Freysteini, Geinitz, Versteinerungen der Steinkohlenformation in Sachsen, 1855, p. 2, pl. xxxv, figs. 7*a*, 7A. *Estheria Freysteini*, Geinitz, Sitzungs-Berichte der naturwissensch. Gesellschaft Isis in Dresden, Jahrgang 1879, p. 10, pl. i, figs. 2*a*, 2A.

Each of these has a straight hinge-line, and a large portion of the valve near the umbo is very much more convex than the rest of the surface.

The specimens of which figs. 7*a*, 7A were given in 1855 were from the Coal-shale of the Scherbenkohlflötze of Oberhohndorf, near Zwickau. Of these there were a few examples measuring 13 × 11 mm.

That one figured as 7A appears to measure—

Size.—Valve, length 15 mm., height 13 mm.; umbonal convexity, length 11 mm., height 9 mm.

There are 19 or 20 strong concentric ridges on the convex part, and 9 or 10 delicate lines traceable on the flat part of the valve.

The "*Estheriæ*" figured in 1879, figs. 2*a*, 2A, came from the Upper Coal-formation, Carl-Schachte, near Lugau, Saxony; and fig. 2*a* appears to measure—

Size.—Valve, length 12 mm., height 10 mm.; umbonal convexity, length 11 mm., height 9 mm.

In some pencil drawings of the same species, kindly supplied by Dr. H. B. Geinitz, the measurements are—

Size.—Valve, length 12 mm., height 10 mm.; umbonal convexity, length 10 mm., height 8 mm.

There are, it seems, 12 or 13 concentric riblets on the valve; and, of these, 6 or 7, on the postero-dorsal area, appear to be delicate lines continuous with some of the coarser ridges of the convexity.

This form as figured in the "Isis," 1879, is obliquely ovate (Pl. VIII, Fig. 10) in general outline. In the "Verstein. Sachsen," 1855, it is shorter and subcircular in outline (Fig. 9). Possibly a sexual difference.

In figs. 2*a*, 2A (1879) the umbonal convexity is subovate in outline; and the flat marginal area is much narrower in front than behind (Fig. 10). The flat margin is narrow and less distinct than in figs. 7*a*, 7A (1855). In the latter (Fig. 9) the umbonal convexity is more nearly subcircular in outline, and the flat marginal area broader and more distinct than in figs. 2*a*, 2A (Fig. 10). The strong concentric ridges on the convex portion and the very delicate lines on the flat parts are well shown, especially in fig. 7A.

§ V. 3, Estheriïna limbata (Goldenberg), 1877.

PLATE VIII, Fig. 11.

Estheria limbata, Goldenberg, Fauna Saræpontana Fossilis, Heft 2, 1877, p. 43, pl. ii, figs. 12 and 14.

The figures of this "*Estheria limbata*," from the Coal-shale near Wemmetzweiler in the Saarbrücken Coalfield, indicate a similar unusual convexity at the umbo of the valve. This form appears to have about 24 concentric riblets, with square-celled interspaces. Of these lines of growth, 15 are strong and prominent on the umbonal region, which is more convex than the rest of the surface; the other concentric riblets are smaller and closer together, "mere lines," on the narrow and flat marginal area or border, whence originated the name "*limbata*."

Fig. 12, magnified six diameters, appears to represent a specimen measuring as follows—

Size.—Valve, length 4·0 mm., height 3·0 mm.; umbonal convexity, length 3·0 mm., height 2·5 mm.

Fig. 14, magnified fourteen diameters, represents a specimen—

Size.—Valve, length 3·6 mm., height 2·4 mm.; umbonal convexity, length 2·4 mm., height 2·0 mm.

It is evident the Brazilian specimens described above, with the umbonal swelling or prodissoconchal boss, differ from both *E. Freysteini*, Geinitz, and *E. limbata*, Goldenberg, by the dorsal convexity having a much smaller area in relation to the size of the valves, and by the other part of the valve in the Brazilian form being expanded to a much greater extent. In its general outline the latter differs from the foregoing European species, although approaching in shape to *E. Freysteini* as figured in the "Isis," 1855 (Pl. VIII, Fig. 9).

If we take advantage of G. O. Sars' careful researches in the life-history of some Estherian forms,[1] we may see that such a persistent swelling near the umbo, as we have in the hump-backed fossils here mentioned, may be said to represent the partly developed test, in its early stages of existence, not so much in the larval

[1] Christiania Vidensk.-Selsk. Forhandl. 1887, No. I; *Cyclestheria Hislopi*, p. 8 et seq., pls. i and ii, vii and viii. Archiv. Math. og Naturw., vol. viii, pt. 1, June, 1896; *Estheria Packardi*, pp. 1–27, pls. i–iv.

(brephic) form as in the post-larval (neanic) stages. Looking at the fossils above mentioned in this light, it seems that *E. Bresiliensis* shows valves of advanced adult growth (having nearly 40 lines of growth) with a prodissoconchal protuberance usually little less than half the size of the valve. The other two forms (*Freysteini* and *limbata*) are also adults (with about 30 lines of growth), and each exhibits an umbonal swelling, having an area little less than that of the whole valve.

This umbonal swelling does not constitute merely a specific difference; it points in all probability to subgeneric or even to generic distinction, as much as the characteristic features of the Triassic *Estheriella*.

Although, without indications of the limbs and soft parts, its separation from *Estheria* can be only provisional, yet it seems to be expedient and useful to recognize this hump-backed form as typical of a genus, with the name of *Estheriïna*.

§ VI. 4, Estheriïna expansa, sp. nov.

PLATE VIII, Figs. 6*a*, 6*b*.

A small, obliquely oval-oblong, flattened, yellowish, and filmy valve exhibiting two different areas of surface; namely, a small subtriangular portion near the umbonal end, bearing a few strong concentric ridgelets, and a larger expanded flattened part of the valve, smooth and shining, with traces of concentric markings and irregular wrinklings. A faint reticulation of irregularly subquadrate meshes is discernible between the riblets on the umbonal region (Fig. 6*b*).

Size. — 7·6 × 5 mm. The umbonal convexity measures 3·0 × 1·6 mm.

In the usual soft light-brownish shale, from a cutting at kilometre 83 from Bahia, between Pojuca and San Thiago.

This is evidently an *Estheriïna*, but different from both *E. Bresiliensis* (Figs. 1–5) and *E. astartoides* (Figs. 7 and 8), agreeing more with the former than the latter. It is interesting to find the same genus (*Estheriïna*) represented at localities fifty miles apart, at 4–5 kilom. (Pedra Furada) and at 83 kilom. from Bahia (near Pojuca).

§ VII. 5, Estheriïna astartoides, sp. nov.

PLATE VIII, Figs. 7, 8*a*, 8*b*.

A small, semicircular, somewhat gibbose carapace; swollen, thick, and marked with strong concentric ridgelets on the moiety of each valve near the umbo, and flattened into a broad, marginal area on the free borders, with faint concentric lines.

A specimen (Fig. 7) that has preserved its normal form measures 3 × 2·6 mm., and the umbonal convexity 2 × 1·5 mm.

Another specimen (Fig. 8*a*) measuring 3 × 2·6 mm. is subovate, having probably been modified by pressure. The convex part has lost its distinctness from the flatter portion for the same reason. Feeble traces of some transverse lineation in the larger concentric

interstices are recognizable (Fig. 8*b*), possibly modified by minute parallel fissures. When crushed obliquely the ridges have been compressed into sharp thin ledges, and pushed back one on another.

The umbonal part is like a small *Astarte*, such as *A. sulcata*, Da Costa, and another small species occurring in these same Brazilian strata, *A. agraria*, A. C. White.[1] The boss is sometimes found by itself; the flatter, thin, outer, marginal, flange-like portion having been shifted away. In the usual soft light-brown shale; from a cutting at kilom. 83 from Bahia between Pojuca and S. Thiago, with *E. expansa*, and between Sargiva and Pojuca.

EXPLANATION OF PLATE VIII.

Fig. 1.—*Estheriina Bresiliensis*, gen. et sp. nov.: *a*, right-hand valve, × 5; *b* and *c*, ridges and interstitial ornament, × 100—one (*b*) near the middle of the valve, the other (*c*) low down near the ventral margin. Brit. Mus. Nos. 13, 37, 371, 372.

Fig. 2.—The same species: *a*, right-hand valve, × 5; *b*, ornament, × 100.

Fig. 3.—The same species: dorsal aspect, × 4.

Fig. 4.—The same species: front end, × 4.

Fig. 5.—The same species: the two valves lying open, × 5.

Fig. 6.—*Estheriina expansa*, sp. nov.: *a*, right-hand valve, × 3; *b*, surface ornament, × 75. Brit. Mus. No. L. 304·4.

Fig. 7.—*Estheriina astartoides*, sp. nov.: right-hand valve, × 10. Brit. Mus. No. L. 304·3, L. 304·4, L. 304·5.

Fig. 8.—The same species: *a*, right-hand valve, slightly distorted, × 10; *b*, surface ornament.

Fig. 9.—*Estheriina Freysteini* (after Geinitz, 1855): right-hand valve, nat. size.

Fig. 10.—The same species (after Geinitz, 1879): right-hand valve, nat. size.

Fig. 11.—*Estheriina limbata* (after Goldenberg, 1877): left-hand valve, × 5.

III.—On a Hornblende-Picrite from the Zmutthal (Canton Valais).

By Catherine A. Raisin, B.Sc.

WHILE staying at Zermatt in the summer of 1894, I searched among the boulders from the Zmutt glacier for several types of rock, which, as suggested to me by Professor Bonney, were likely to occur. I am further indebted to him for kindly giving me his help and opinion on several questions while I was writing this note.

One specimen which I collected proves to be rather different from the rocks recorded from that district, and has points of interest. The boulder was rather large (roughly about 2 feet across), and it lay by the side of the path, on the right bank close to the glacier near its termination, where the moraine material is thickly heaped upon the ice, and many boulders are strewn along the side.

The rock is blackish, with scattered specks of a soft white mineral, and with glittering cleavage surfaces of crystals which appear lustre-mottled. It attracted my notice from its resemblance to a picrite, and especially to the Penarfynydd rock.

[1] The subtrihedral shape of these Astartes is wanting here, and they are too large. *Astarte agraria* measures 20 mm. × 19 mm., and the thickness of the carapace is 12 mm. *A. cælata*, Münster, about 5 mm. long; *A. planissima*, Forbes, has definite Molluscan characters, and is about 12 mm. long.

On examination with the microscope the olivine is seen to be fresh-looking, forming the usual rounded grains with reticulate structure, where alteration is just beginning. At one part of the slice, around the olivine and separated from it by a sharp, sometimes crystallographic boundary, is clear unaltered hornblende, often extending as a large crystal enclosing many grains. It is brownish, dichroic, exhibits low brownish tints with crossed nicols, and well-marked cleavages along which deeper-coloured rhomb-shaped inclusions are often ranged — examples of Professor Judd's schillerization enclosures. These apparently have a tendency to be formed along an internal zone of the crystal.

At another part of the slide, the olivine is imbedded within a mineral generally colourless, much of which is undoubtedly augite.[1] Sometimes, however, a faint dichroism, a brownish colour, and characteristic lattice cleavage are exhibited, and it seems as if the augite is changed to hornblende.[2] At one part a bordering mineral similarly related to the olivine, but having a close fibrous actinolitic structure, like the pilite of Becke, may be a further modification of the original pyroxene.

The third important constituent (forming the white specks seen macroscopically) is a mineral, now mostly a dusty-looking opaque substance, but often changed at least at the exterior to serpentinous or some non-polarizing aggregate. Remains of one good cleavage and sometimes of a cross cleavage are well marked, and the mineral seems to be decomposing bastite or steatite. The rhombic pyroxene apparently developed late, filling up the interspaces between the hornblende. At one side of the slice a large crystal of fresh-looking enstatite[3] surrounds the olivine, and is intercrystallized with some of the bordering hornblende and even with some of the decomposed bastite.

It thus seems as if the monoclinic was the first of the pyroxenes, starting and forming on the edge of pre-existent olivine, but was in some cases speedily followed by the orthorhombic pyroxene. Thus, occasionally a large crystal of augite or hornblende occurs, lustre-mottled by the olivine, but the extended crystal may be represented only by rims, and bastite may fill up much of the space.[4] This at places gives to the latter the aspect of an inclusion, but its form shows that it followed the olivine and was not a contemporaneous formation.

The spinellid is pleonaste of a rather bright green colour, often in partly rounded grains, occurring sometimes within hornblende,

[1] It is usually not dichroic, exhibits well-marked cleavage planes, and the high extinction angle of augite.

[2] As described by Professor Bonney, "On the so-called Diorite of Little Knott (Cumberland), with further remarks on the Occurrence of Picrites in Wales": Q.J.G.S. 1885, vol. xli, p. 520.

[3] The enstatite has close parallel cleavages which almost seem to form a repeated twinning, but this (examined with a high power) is seen to be an effect of a large number of elongated vesicular-looking enclosures, which are probably negative crystals formed along gliding planes. Cf. Prof. Judd, Q.J.G.S. 1885, vol. xli, p. 354.

[4] This may possibly indicate a local deficiency of lime in the magma, a thing not surprising, as peridotites are often ill-mixed rocks.

as if moulded along the cleavage planes, and sometimes within serpentine. Pyrites occurs within the enstatite and the hornblende.

As in other picrites, certain minerals act as a groundmass, which varies even in one slide. The order of consolidation seems to have been—(1) olivine, (2) pleonaste, (3) augite and hornblende or enstatite, (4) a second variety of enstatite, now steatitic.

The rim bordering the olivine grains is occasionally penetrated by serpentine or chrysotile. This is deposited apparently along cleavage planes in narrow spaces which extend beyond as forked branching canals, suggesting a more irregular fracturing. The canal part reminds us somewhat of an 'eozoon' structure, as was remarked by Professor Bonney in noticing a similar development in a troctolite.[1] It is also like the structure in gelatine figured by Professor Sollas,[2] and similar to specimens which I have obtained in some simple experiments. In the last case, at least, the cause seems to be a cracking of the material, the cracks often having certain more regular cavities as starting-points. Similar canals are found in the slide here described along rather regular cleavage planes in part of a crystal which resembles bastite, and some of the dusty decomposed patches of that mineral resolve themselves in a thin slice under a high power into a system of what look like very fine tubules. In a gabbro from Portsoy, Professor Judd describes radiating cracks as caused by the "expansion of the olivine during its hydration," and injected with serpentine.[3] These cracks are generally well seen in the troctolites, and Mr. Harker refers to this character in the Lleyn picrite.[4] In the Zmutthal specimen, a definite and limited rim around the olivine seems to be penetrated, thus producing a more regular form of a canal system.[5] As to the origin of the structure, while the expansion from hydration may have acted as one cause, it seems probable that the mode in which the mineral originally crystallized (possibly from its narrow area) developed certain planes of weakness, not at first recognizable, along which corrosion or fracture could afterwards act.

The boulder which I am describing is probably connected with other rocks from this neighbourhood, although it is distant from them. One of these contains unchanged olivine—the olivine-gabbro of the Matterhorn[6]—in which the occurrence of green pleonaste

[1] "On Bastite Serpentine and Troktolite in Aberdeenshire": Geol. Mag. 1885, Decade III, Vol. II, p. 444, note.

[2] Trans. Royal Irish Acad., vol. xxix, pp. 462–3.

[3] Q.J.G.S. 1886, vol. xlii, pp. 94–5, pl. vii, fig. 7.

[4] Q.J.G.S. 1888, vol. xliv, p. 455.

[5] In my specimen of the Penarfynydd picrite, which I collected in 1885, the olivine contains, sometimes at the edge, clusters of needle-shaped structures either parallel or radiating in a stellate form, the needles in both cases suggesting minute fissures starting from a centre. At places the parallel bundles seem to be connected with a fibrous chrysotile development.

[6] T. G. Bonney, "On some specimens of Gabbro from the Pennine Alps": Min. Mag., April, 1878. T. G. Bonney, "Petrological Notes on the Euphotide or Saussurite-Smaragdite Gabbro of the Saasthal": Phil. Mag. 1892, vol. xxxiii, ser. 5, p. 237. R. W. Schäfer, Tschermak Min. and Petr. Mitth. Wien, Bd. xv, Heft. 1 and 2, 1895, p. 132.

has been noticed. In that rock, however, felspar is present, described as plagioclase and idiomorphic. In the boulder, the dusty-looking or opaque white substance clearly is interstitial, and is now steatite, a decomposition product of a rhombic pyroxene. The specimen appears to be nearest to the group of the picrites, to the form of that rock not containing felspar. It is somewhat intermediate between the typical augite-picrite and the variety distinguished by Professor Bonney as hornblende-picrite, and it has a likeness to the Penarfynydd rock.[1] So far as I am aware, it has not been recognized *in sitû* in the Zmutt district, and it will be interesting if any climber in that neighbourhood should track it to its home. The boulder being large, it most probably came directly from some of the neighbouring heights, possibly from the western side of the Matterhorn, gabbro, according to the Swiss map, occurring from the watershed down at intervals to the neighbourhood of the Zmutt glacier. This hornblende-picrite is interesting as another variety of the basic igneous rocks, varying from serpentine to gabbros, which form a widespread group, extending at least from the Saas Valley to the Val d'Hérens.

IV.—On the Subdivisions of the Carboniferous Series in Great Britain, and the True Position of the Beds Mapped as the Yoredale Series.

By Wheelton Hind, M.D., B.S.Lond., F.R.C.S., F.G.S.

(*Concluded from the April Number*, p. 169.)

THE earlier part of this paper is devoted to a short epitome of the stratigraphical evidence that the Yoredale rocks of Wensleydale are only the equivalents of the upper part of the Carboniferous Limestone, and that the so-called Yoredale Beds of South Yorkshire, Lancashire, and Derbyshire are an entirely different series, which occupy a position above the Carboniferous Limestone. After all, the important point is the palæontological evidence, which, to my mind, is absolutely conclusive.

On comparing the Molluscan fauna of the limestones and shales of the Yoredale Rocks of Professor Phillips with that of the Carboniferous Limestone of Derbyshire, it is at once seen that they are practically identical. In the list of fossils given in the Appendix to the Geological Survey Memoir on the country round Mallerstang,[2] 110 named species of corals, echinoderms, annelids, crustaceans, polyzoa, and mollusca are enumerated, the great majority of which are common to the Yoredale Series and Great Scar Limestone. But no species occur which are peculiar to the upper beds, and which do not occur in the massif of Carboniferous Limestone in one locality or another. On palæontological grounds, therefore, no distinction can be drawn between the Yoredale Series of Wensleydale and the main mass of Carboniferous Limestone, though it would not have been surprising, considering the differences of lithological character

[1] Cf. T. G. Bonney in Geol. Mag. 1880, p. 208. A. Harker, loc. cit.

[2] Explanation of Sheet 40, Geological Survey.

in the deposit, if such had been the case. Not only do the Yoredale Rocks of the Wensleydale area contain no distinctive fossils peculiar to themselves, but many species recur again and again in beds separated from each other by many feet of different strata, in which often plant beds occur and at times well-marked seams of coal, proving that terrestrial conditions obtained between deposits containing a similar fauna. There is no possibility, thanks to the nature of the ground, that the series of limestones are only one bed, repeated by a succession of folds; and the only alternative is, that owing to an unsuitable environment the fauna migrated and lived on in an outside area, ready to return when suitable conditions obtained. This was, of course, Barrande's theory for his "colonies," for the truth of which it would appear that the Carboniferous rocks afford abundant evidence, and the series of Carboniferous rocks in Scotland give a good example.

In Scotland, beneath the Coal-measures, there is a long series of alternating beds of sandstones, shales, limestones, and coals as an upper division, and the Calciferous Sandstone Series as a lower division, consisting of shaly clays and argillaceous limestones, oil shales and sandstones. The fossils characteristic of the Carboniferous Limestone of England are found throughout the upper series in those beds which are of marine origin, and occasionally in thin bands in the Lower or Calciferous Sandstone Series. In the beds of this series on the Fifeshire coast, Mr. J. W. Kirkby, of Leven, has enumerated no less than eighteen such marine horizons distributed chiefly in the upper and lower portions of 4000 feet of strata ("On the Zones of Marine Fossils in the Calciferous Sandstone Series of Fife": Quart. Journ. Geol. Soc. 1880, vol. xxxvi, p. 559). One hundred and fifty-two species are enumerated, of which only seven appear to be new and therefore, as far as is known at present, peculiar to the series; but a few others belong to fresh- or brackish-water beds.

It is curious to note that between 500 and 2280 feet no marine bands have as yet been discovered, and only four occur in the first 600 feet; the 1780 feet of intervening beds being composed of repeated alternations of sandstones of various colours, shales, marls, and ironstone bands, in several of which, but chiefly in the argillaceous beds, plant-remains are fairly plentiful.

It is evident, too, that the Carboniferous Limestone fauna did not die out with the close of that period, even as expressed in the rocks of the Derbyshire-Yorkshire area; for, although absent from the strata for intervals of time represented by many hundred feet of deposit, there are occasional recurrences of certain typical fossils of that fauna in certain widely separated localities at different horizons.

Mr. J. Ward has shown three bands with a marine fauna to exist high up in the North Staffordshire Coalfield, two of which contain several well-known Carboniferous Limestone species, the third only *Lingula squamiformis*. I make no mention of the marine bands containing *Goniatites Listeri* and *Aviculopecten papyraceus*, as these

shells do not belong to the fauna contained in the limestones. At Coalbrookdale *Spirifer bisulcatus* and *Productus scabriculus* occur with other marine shells in the Penneystone Ironstone of the Coal-measures, which, however, do not occur in the Carboniferous Limestone.

In a bed of shale containing calcareous bullions, situated above a gannister-like sandstone, some little distance below the third bed of Millstone Grit on Congleton Edge, is a fairly rich fauna, containing, amongst others, *Productus* (four species), *Spirifer*, *Athyris*, *Orthis*, *Streptorhynchus*, *Chonetes*, *Terebratula*, *Discina*, and *Lingula*, all of which are found in the limestone, but are absent in all the intervening beds. It is difficult to arrive at any satisfactory conclusion as to the whereabouts of this Carboniferous sea in which the limestone fauna survived, and it is questionable if a discussion of the matter would be productive of any benefit.

The proper fauna of the beds between the Millstone Grits and the Carboniferous Limestone in the Yorkshire-Derbyshire area is a very typical one, though not peculiar, in any particular, to this horizon; in fact, it is identical with the fauna which is found in the marine beds of the Gannister Series of the Lower Coal-measures. The evidence for this fact has been lately much increased by the collections of Messrs. Holroyd and Barnes, in the beds exposed below the Millstone Grits in the valleys round Marsden and Saddleworth, and from the beds passed through in the London and North-Western Railway tunnel under Standedge Moor. I have been over the ground with these gentlemen, and have had the opportunity of gathering the fossils myself as well as of studying the fine series that they have collected during the last few years. The fauna is, taken as a whole, very similar to that which has always been considered characteristic of the Gannister Series of Lancashire, several species being identical with those found in the nodules of the roof of the Bullion Coal. Very few species, indeed, if any, are common to it and the Mountain Limestone fauna; but the three genera *Carbonicola*, *Anthracomya*, and *Naiadites*, which are so frequent in the Coal-measures, are all represented, the former by at least four well-marked species; and the shells themselves cannot be in any way distinguished from those occurring in the Coal-measures. It may be therefore emphatically stated, that the fauna of the shales which are situated below the Millstone Grit in South Yorkshire is totally distinct from that which characterizes the shales and limestones of Wensleydale.

Though not known to be so rich in species, the shales of Derbyshire and North Staffordshire contain a similar fauna, several species of *Goniatites*, amongst which *G. reticulatus* is conspicuous, *Aviculopecten papyraceus*, and *Posidoniella lævis* occurring at several horizons. In Cheshire, however, on Congleton Edge, situated some 200 feet below the base of the Millstone Grit, here represented by the third, Rivelin or Roaches grit, is a bed of black shales in which are layers of calcareous nodules, which overlies a hard, fine, gannister-like quartzose rock. These concretions contain a rich

fauna, which, although peculiar with regard to its Lamellibranchs and Gasteropods, has a plentiful Brachiopod fauna, consisting of typical Carboniferous Limestone forms. The following species have been collected in this quarry by myself:—

Terebratula hastata.
Spirifer glaber.
,, bisulcatus.
Athyris planosulcata.
,, ambigua.
Orthis resupinata.
Streptorhynchus crenistria.
Productus semireticulatus.
,, longispinus.
,, cora.
,, scabriculus.
Chonetes Laguessiana.
Discina nitida.
Lingula mytiloides.

LAMELLIBRANCHS.

Myalina peralata.
Modiola transversa (Hind).
Nucula gibbosa.
,, æqualis.
Edmondia, sp.
Sanguinolites, sp.
Posidoniella semisulcata (Hind).

There are also several forms of *Goniatites*, *Nautilus*, *Orthoceras*, with Gasteropoda and Crustacean remains, including *Dithyrocaris testudineus*. It is to be noted that, although the Brachiopoda are Lower Carboniferous forms, the Lamellibranchs are peculiar.

Many fossils have been obtained from the shales in the neighbourhood of Todmorden, several of which are to be seen in the Manchester Museum, Owens College. This fauna is a very singular one, and remarkable for the number of species.

The nomenclature and lists given by authors are, however, not to be trusted, most of the forms having been named by Captain Brown, and the vast number of the names are only synonyms. Still, several forms of *Posidoniella* are present, of which, after an examination of all the types, fortunately preserved at Owens College, I recognize *Posidoniella lævis* (Brown), *P. minor* (Brown), *P. Kirkmani* (Brown), *P. variabilis* (Brown), *P. subquadrata*, sp. nov., *Aviculopecten papyraceus*, Sow., *A. fibrillosus*, Salter, *Nucula gibbosa*, Fleming, *N. æqualis*, Sow., *Goniatites reticulatus*, *G. stenolotus*, *G. carbonarius*, *G. Listeri*, and at least two new species.

J. W. Davis quotes ("West Yorkshire") four species of *Nautilus*, ten species of *Goniatites*, fourteen species of *Orthoceras*, together with a very rich Gasteropod fauna, from the same bed. I am not well enough acquainted with these groups to say anything as to the value of the large number of species here enumerated, but the common Mountain Limestone species are all conspicuously absent.

With regard to the Brachiopods, only three are mentioned by authors—*Orthis resupinata*, *Productus Martini*, and *P. antiquatus*, Gibson; but I have not seen these specimens, and from the curious nomenclature nothing can be said at present as to what species occur at Todmorden; still, the essential fact remains that, on the whole, Brachiopoda are conspicuously absent.

The shales of Flasby are credited with a long list of *Goniatites*, among which are *G. Listeri*, *G. Longthorni*, and *G. reticulatus*, all of which occur in the Gannister Series of the Lower Coal-measures.

Viewing, therefore, as a whole the fauna of these shales, it cannot

but be noted that it is totally different from that of the Mountain Limestone, and also of the Yoredale Series of Wensleydale; and the question at once arises as to the correctness of applying the term Yoredale to them, seeing that they differ so essentially, both lithologically and palæontologically, from those beds to which the term was originally applied. There is in these beds an absence of the limestones which are so characteristic of the series in Wensleydale, and this may at first sight appear to account for the difference in the faunas; but, as a matter of fact, some of the shales in Wensleydale are far richer in organic remains than the limestones, and these remains are typically those which occur in the great mass of limestone.

Indeed, if my contention be correct, that the Yoredale Series of Wensleydale is the homotaxial equivalent and also the chronological representative of the massif of limestone so typical of Derbyshire, then the black shales of North Staffordshire, Derbyshire, and South Yorkshire belong altogether to a higher horizon and are not in any way the equivalents of any beds of the Yoredale Series. If stratigraphical division be necessary, the only reliable data, in the absence of unconformity or some well-marked change of lithological character, are of a palæontological nature; and this evidence points undoubtedly to a closer biological connection between the so-called Yoredale Beds of Derbyshire with those above, and the Yoredale Beds of North-West Yorkshire with those below. It appears to me that the so-called Yoredale Beds of Derbyshire and Yorkshire should really be included in the Millstone Grit Series, as they contain a very similar fauna and flora, and, moreover, certain very well developed sandstones, often extremely difficult to separate on lithological grounds from true grits.

There are three very different molluscan faunas in Carboniferous rocks, and I have yet to be convinced that they are actually intermingled in the same bed, though there can be no doubt that they overlap each other somewhat.

No. 1.—The Coal-measure fauna, rich in fish-remains, with the molluscan genera *Carbonicola*, *Anthracomya*, and *Naiadites*; essentially a fresh-water fauna.

No. 2.—The Lower Coal-measure and Grit fauna, the Gannister and Grit Series, largely marine, but littoral; *Aviculopecten*, *Posidoniella*, *Goniatites*, *Orthoceras*, *Nautilus*, and peculiar Gasteropoda.

No. 3.—The Limestone fauna, essentially marine, rich in corals, Polyzoa, very rich in Brachiopods; with *Pecten*, *Avicula*, *Edmondia*, *Sanguinolites*, and many other genera of Lamellibranchs, Gasteropods (*Euomphalus*, *Pleurotomaria*, *Murchisonia*, *Loxonema*, etc.), and Cephalopoda, Corals, Crinoids, and Fish-remains, many of these being peculiar to certain beds.

In a few localities, as at Congleton Edge (vide p. 207), we find a curious fauna, which would appear to be a mixture of a few of the Brachiopoda of the Limestone with a fauna on the whole

somewhat approaching that which obtained in the middle of the Carboniferous Series; but here, as at Coalbrookdale, it is only the Brachiopoda of the lower beds which are present, and this family appears to have comprised the hardiest and most able of all forms of life to assimilate themselves to altered conditions.

These differences are due to bathymetric conditions, and the overlapping of the faunas to a return to conditions suitable for each group of organisms.

In the North Midlands the fossil flora is abundantly present, with the first fauna: present only in the sense of occurring in beds intercalated with the molluscan-bearing beds, except in the roof of the Bullion Coal, where there is drifted woody material in abundance. The flora is practically absent in the beds containing the lower fauna.

In Northumberland and Scotland the peculiar fauna characteristic of those shales which occur below the Millstone Grit in South Yorkshire is absent, although one or two species are quoted, but no reliance can be placed on the nomenclature of the Goniatites at present.

Aviculopecten papyraceus, so characteristic of these beds, is quoted by John Young ("The Carb. Foss. of the West of Scotland," p. 47) as rare, and it is noted by the Palæontologists of the Survey as occurring in shales some distance above the Ell coal (Wishaw district), and in the shale above the Calderwood cement-stone (E. Kilbride district: Mem. Geol. Surv. Scotland, Explanation of Sheet 23) is very much lower down, but in neither case do the other members of the fauna occur. This species is said to occur in the Carboniferous Slate of Clonakilty, co. Cork (Bailey), and in Carboniferous Limestone near Harrogate and Bolland (Phillips); but there is the gravest doubt in my mind as to the correctness of this specific determination, for according to my own observations this species is never found in the Carboniferous Limestone, but is characteristic of the Lower Coal-measures and Millstone grits and the shales below them.

I have shown (Pal. Soc., vol. xlix, Monograph on *Carbonicola*, *Anthracomya*, and *Naiadites*, pp. 82–145) that the genera *Carbonicola* and *Naiadites* both occur low down in the Calciferous Sandstone Series of Fifeshire, but that the species are different to those occurring in the Coal-measures; and I have pointed out that, similar conditions of deposit being suitable, the same genus returned at several horizons. In the slates of South Yorkshire not only do the same genera occur as obtain in the Coal-measures, but a very large number of the same species are common to the two horizons. These shells must have survived in some outside area, during the deposition of the intervening beds in which they are absent, to return when conditions became again suitable for their migration and survival. This theory demands, not that the beds of one deposit are continuous with other beds at two and more widely separated horizons, but that both beds, containing a practically identical fauna, were the result of one successively continuous series of events. This

argument, of course, applies equally well to those beds which have the typical Carboniferous Limestone fauna.

Now, if carried to its ultimate conclusion, the fact of the presence of these beds containing a Carboniferous Limestone fauna at various horizons in the Black Shales (Congleton Edge), the Millstone Grit (Sawley, near Ripon), the Lower Coal-measures (the roof of the Bullion Coal), and in the Coal-measures themselves (the Penneystone of Coalbrookdale, the roofs of the Gin Mine and Bay Coal, North Staffordshire), emphatically proves Sir Andrew Ramsay's contention that the Carboniferous system was one great succession without a break; because the fauna characteristic of its lowest beds survived during the whole of its duration, a few species probably being preserved into Permian times. But, notwithstanding this unity, there is a well-marked line along which a division can be made into Upper and Lower Carboniferous, for which there are strong grounds, both lithological and palæontological, that is, where limestones of typical marine character ceased to be deposited, and shales and grits with coals took their place, denoting a shallower water and more frequent return to terrestrial conditions, and containing a fauna for which these conditions were suitable.

I have shown in the introduction to my Monograph on the British Carboniferous Lamellibranchiata (Pal. Soc., vol. L, 1895, pp. 10–15) that the Carboniferous series as developed in Great Britain and also in Europe and North America, lend themselves best to a twofold classification, which I have summarized as Upper Carboniferous or Anthraciferous, and Lower Carboniferous or Calcareous series; and I need not enter further into detail here.

This base line of the upper division would, in Derbyshire, North Staffordshire, and Yorkshire, be at the top of the uppermost thin limestone; for in a few localities the massif of Carboniferous Limestone was succeeded by a short series of passage beds, containing thin limestones with a Carboniferous Limestone fauna, e.g. Butterton Moor, near Leek (Proc. Geol. Assoc., vol. xi, pp. cxxxi, cxxxii); and in the Wensleydale district and Northumberland the topmost bed of limestone would also form the limit, and this line of division is really a palæontological one, and not lithological, because it is at this horizon that the characteristic fauna of the Carboniferous Limestone series ceases to be persistent. The beds above the limestones would then be Upper Carboniferous, and would include the shales below the grits, the grits, and Coal-measures, characterized by faunas No. 1 and No. 2.

There is a great similarity between the deposits of this series, there being several workable coal-seams in the grit series, and many beds of coarse sandstone in the Coal-measures; and in addition, the whole of this series is characterized by an absence, with rare exceptions, of marine conditions. There occur frequent interruptions in deposit due to terrestrial conditions, and, moreover, the palæontology of this series is as a whole very different from that which obtains in the beds below, and is peculiarly characteristic of it.

Some objection may be taken to this division from the fact that

several beds of limestone occur at various horizons in the Coal-measures. But these beds have, as far as is at present known—and I have examined several, and many have been reported upon by officers of the Geological Survey and others— a totally distinct fauna to that which is entombed in the lower limestones; the one difficulty in the Midland area being whether to place the Pendleside limestones in the lower or the upper division. My own view is, that the fossils agree more with the fauna typical of the Carboniferous Limestone than with those above.

Again, it may be asked, why, with three distinct faunas, make a twofold division? and the answer is that, although it would be impossible to draw any line of demarcation between the beds containing faunas No. 2 and 1, which are so much intercalated, the fauna of the lower series is so characteristically different; or, with greater reason, it may be asked why even a twofold division? The reasons for this are, first, that a review of the Carboniferous rocks of the world seems to demand such; and, moreover, the fauna of the limestones, although it did occasionally reappear for a brief period in the upper beds, is so typical of the lower beds; and I claim that the binary division of Carboniferous rocks is therefore based solely on palæontological grounds. Mr. R. Kidston considers that the plants distributed through the Carboniferous rocks "clearly indicate a great twofold division," and in the main his division is identical with mine, although he does not appear to recognize that the Yoredale Series of Wensleydale is only the equivalent of the upper part of the Carboniferous Limestone; but as he says that he has seen no plants from that series, and had no personal knowledge of that district, he has not based any evidence for his classification on those beds.

Geological science knows no hard and fast lines, and classification, though founded on natural laws, is not a law of nature, but purely utilitarian in purpose; but to be of any service at all, even the classification and division of series of strata must be based on the soundest palæontological evidence.

The recognition of the true place of the series of rocks in Wensleydale, although, of necessity, abolishing the term Yoredale Series as one of the primary divisions of Carboniferous rocks, does not render it obligatory for that term to altogether sink into disuse. The name may very well be used to denote the change of character in the series, due to causes which acted locally, and to represent the Carboniferous Series as it occurs in Wensleydale, Swaledale, Teesdale, and the upper parts of Wharfedale and Ribbledale. But the use of the term must be restricted to this district, and beds of an altogether higher series, with a totally different fauna, must be no longer confounded with them because they appear to occupy a position between two arbitrary and discontinuous base-lines. Currents, reefs, and the differences in depth of a shelving shore, will account for any of the difficulties of tracing any one bed for a distance; and it must be remembered that much of the deposits must have been extremely local, and that many strictly synchronous

deposits must have differed entirely in their composition and mode of deposition, and that denudation will not account for all the apparent breaks which are discovered on attempting to map a district.

NOTE.—Mr. Morton writes that in the North Wales series, mentioned on p. 165, "the Arenaceous Limestone and Upper Black Limestone are one and the same subdivision."—W. H., April 15, 1897.

V.—WATER *VERSUS* ICE AS AN EXPLANATION OF THE SURFACE BEDS OF EASTERN ENGLAND.

By Sir HENRY H. HOWORTH, K.C.I.E., M.P., F.R.S., F.G.S.

IN former papers on the surface deposits of Eastern England. I have analyzed the conditions of their occurrence and the character of their contents in view of the current theory which makes them the products of ice during an Ice Age. I have endeavoured to show that, tested by every empirical method, they utterly fail to sustain such a conclusion;—that in every character by which we can test these beds, or their component parts, they clearly and emphatically point to some other origin and cause than that of ice; and, on the other hand, that ice such as it is known to us, either in our laboratories or in Nature's laboratory, is quite incapable of producing the results demanded from it by the champions of the Glacial School who have discussed the surface geology of Eastern England. This negative conclusion is, of course, a very important one when we consider what a dominating influence this School has at this moment, not only among official geologists, but among the pundits of Burlington House, where Lyell's followers have pushed their master's teaching to the most extravagant and outrageous length.

If ice be an impossible cause of the phenomena we wish to explain, and if the teaching of half a century on this question will certainly in great part have to be reversed, whither are we to turn, except to the cause which satisfied the *Patres Conscripti* of our science in the days when, before a man became a geologist, he thought it necessary to have a wide and generous training in other sciences and branches of knowledge, men who were mathematicians and physicists as well as geologists, who were in the habit of verifying the capacity of the causes to which they appealed, and who were not tied to some preposterous scholastic prejudice like the theory of Uniformity. They appealed without doubt or difficulty to Water and not to Ice as the main and the efficient explanation of the phenomena of recent geology. At their feet I learned what I know, and by their creed on this question facts and logic both compel me to abide. Water has this supreme claim over Ice, that, whereas the phenomena to be explained absolutely refuse to conform to the proved qualities of ice, they are all consistent with the qualities and characteristics of water. There is not one of them which is not so. Water can carry as heavy weights as ice, and can carry them as far.

Water loaded with stones can score and tear the surface of a country and can make striæ on boulders. Water in great volume, and moving headlong, can sweep with it great banks of clay and loam, and throw them down in heterogeneous disorder. These are the principal earmarks of phenomena supposed to be especially glacial. On the other hand, water, and water alone, so far as we know, can roll angular stones into subangular and rounded boulders. Water alone can sift out and separate clays and gravels and sands according to their several specific gravities. Water alone can traverse a country and pick up as it passes along the débris it meets on the way and mix it together, and then, when arrested, or from some other cause, break sporadically in various directions, carrying its load hither and thither. Water coming from different directions can bring the tribute of different districts into the same cauldron. Water in great masses and moving rapidly can traverse a country irrespective of its surface formation, and mantle it over with continuous beds of softly outlined contour, leaving a great load under the lea of some obstruction, and sweeping clean the places where its current forms a "race." Water drops its load according to its specific gravity, the heavy burden generally first and the light one later. Water can mix tender shells with other and harder materials and carry both together, and lay them down together. Water can take up great masses of soft materials and redeposit them without breaking their continuity. It is continually removing masses of turf and bog in this way. Water alone can, so far as we know, arrange beds and sands in long continuous fine laminæ, marked by every variety of gentle curve. Water alone can take up masses of clay and lay them down on stratified sands without breaking up their layers of stratification. Every difficulty which we have criticized as inconsistent with the handiwork of ice disappears if we admit water as the alternative postulate. This was seen and conceded by the great masters of old days, Sedgwick and Conybeare, Hopkins and Murchison. It is said in light and airy fashion that these men had not our materials to work upon, nor our powers of generalization. I wonder in what single respect these old men fell behind when facing great dynamic problems like the one we are discussing. What men now living can claim the tremendous experience, grasp and knowledge, the clear vision and unflinching logic, of some of the greatest of these old heroes?

But we are told they lived before the sun of geology had really risen. These old men, it is true, had not realized that modern geology would become a deductive and not an inductive inquiry, like every other science, nor could they know that its real corner-stone was not to be finally laid until Ramsay formulated, from the Chair of the Geological Section of the British Association, that splendid product of modern scientific logic, namely, the dictum that Nature had never, either in kind or degree, exceeded her present methods or employed greater and more far-reaching powers. This is the shorter Catechism of the New Faith, which is to dissipate that of the older Prophets. Francis Baron Lord Verulam, let me take off my cap to

thee! What dost thou think of at least one science as it is taught in the end of the nineteenth century? I am not alone in my protest. What a remarkable thing it is to read in the pages of so ardent a Glacialist as Mr. Carvill Lewis, for instance, when, having told us the great Chalky Boulder-clay occurs only in non-glaciated areas (p. 216), he despairingly asks if it be not due to torrents of water rushing westwards and bearing cakes of ice? (p. 233, note).

That water could do what is needed, I know no one who disputes. That it could do what ice could not do, some of us think we have shown; but the necessary conditions are, that it must not be water acting in a normal way, but in very large quantities and moving very boisterously, and this is the crux that is so hard to face by the patrons of scholastic science, and hence why those who claim to explain phenomena by adequate and not inadequate causes are not answered seriously, but are remitted to ridiculous references to Noah and his Ark, and treated to other absurdities of a despairing logic. Even the good souls who feel that to water we must eventually turn for the greater part of our explanation are constrained to put themselves in a straight jacket and to try to make a pail of water do that which requires a reservoir, and this entirely because Lyell or Ramsay or some Pope has issued an encyclical *De Uniformitate.*

Thus one school of geologists invokes a general and long-continued submergence, during which fleets of icebergs were floating about the whole land, and travelling between Shakespeare's birth-place and Tennyson's, and between the land of Burns and that of Cowper. Such a submergence, proceeding gently and lasting long, is supposed to in some way square better with the tender feelings of Uniformitarians; and as one submergence is not enough and fails to account for the phenomena, others postulate, with the greatest *sang froid,* several elevations and sinkings to the extent of 1,000 feet or more, as if they were the most ordinary occurrences in Nature, and as if these good Uniformitarians were not living on an island which, so far as we can judge by the evidence, has not moved either up or down for at least 2,000 years. So long as the movement is exceedingly slow, so long as there is nothing spasmodic or cataclysmic in it, it is thought to be consistent with the eternal laws of Nature, however wild and extravagant is the postulate. Hence the readiness with which the theory of submergence, qualified by ice-bergs as the cause of the surface phenomena of these islands, has found so much favour. Let us analyze it a little. There is no scalpel so effective in dissipating a geological tumour as a little analytical sifting of details.

In the first place, if we are to account for the Chalky Clay by a submergence, we must carry the submergence as far west at least as Warwickshire, and we must put the whole country under water from the Tees to the Thames.

If the phenomena of the distribution of the boulders are to be explained by the portage by icebergs, then it also follows that Mount Sorrel and the other high ground in Leicestershire, as well as the Chalk Downs of East Anglia and Lincolnshire, must have

been completely submerged. If so, how is it possible for the icebergs to have got their loads of native stones at all, for the whole country available for stones would be submerged, and floating bergs cannot collect stones from the sea-bottoms over which they are floating. Nor could such bergs get the stones on their backs, for icebergs are merely the terminal feet of glaciers which have calved off, and, as we have shown, there were no glaciers in Charnwood Forest and there are no remains of ice-action there. So much for the local boulders: now for the strangers. How were icebergs to collect their load of stones in Cleveland and Lower Durham, when Eastern England was submerged at least a thousand feet? But these stones, like those from the Christiania Fjord, are mostly rounded boulders or subangular blocks. They must have been rolled and worn by some force before they were picked up and scattered. How could icebergs collect them?

Having collected them, how could they proceed to scatter them over the wide area of the Chalky Clay and its associated beds, and leave them not in heaps, but sporadically; and how could these icebergs come down upon Eastern England from almost every point of the compass? On the banks of Newfoundland, in Baffins Bay, in the South Pacific, wherever, in fact, we have streams and fleets of icebergs depositing loads of stones, they all have a uniform route. Nor can we see why, if the march of the old icebergs were divergent, the boulders from Norway should occur nowhere on the British coasts except between Robin Hood's Bay and Cromer.

Nor, again, can we see how by any possible means icebergs could either get hold of or move about or transplant the enormous cakes of chalk, oolite, etc., many hundreds of yards in length, whose portage has been attributed to them, or underlay them with soft drifted sand and clay. If they were foreign bergs floating in, how could they by any means take up and detach these monster boulders. They could not get them on their back, and it is impossible to understand how they could get them attached to their feet. Floating bergs cannot get frozen to anything. What applies to the bergs, applies also to shore-ice. Shore-ice will, no doubt, move stones along shore, and sometimes push masses of stone up sloping beaches, but shore-ice cannot perform the feat of taking up great masses of chalk and depositing them in beds of loamy sand with their laminations intact. Besides, shore-ice implies a shore, and how is it possible to have a shore at Cromer or in Mid-Lincolnshire where the postulate is, that the whole country was submerged a thousand feet deep. Nor are there any traces of old beaches or shores to be found where these great stony masses occur. Floating or shore-ice, therefore, seems out of the question as a cause of the boulder formations of Eastern England. Let us, then, turn to the supposed handiwork of the sea during a prolonged submergence. Does the eastern half of England look in the least like an old sea-bottom. If it were submerged for any considerable time, where are the marine débris, the shells, etc. There is literally not a single specimen known to me, for, as we have seen, the shells once supposed to be glacial shells in certain local maritime

districts are all derivative and belong to the horizon of the Norwich Crag. The question has been asked over and over again, and bears repeating. It is literally incredible that such a wide district should have been submerged without leaving a trace of shells or other marine débris to attest it; but this is not all. If the submergence were gradual and the upheaval the same, we ought to have endless traces of beaches and shore-lines. Where are they? Again, how could the sea mix the contents of the Chalky Clay, and distribute them as we find them over hundreds of square miles of country? Nothing is plainer than that the active operations of the sea are carried on within a very short distance of the shore. It is only there that wind and current chiefly work, and that gales and storms are effective. In deep water and away from the shore, the bottom is quiescent, and we have virtually no dynamical action. How, then, are we to understand the bringing together and mixing of the rocky débris of the surface beds and their distribution, as we find them, by means of ocean-waters, the deposition of the clays and the sands and gravels in the extraordinary way we find them, the occurrence of the Chalky Clay only on one side of the chalky downs, the general drift of the materials in one direction from their old source, and the sporadic scattering of the mixture in all directions? There is literally not one single feature in these beds which seems to me to be consistent with their having been the product of a long-continued marine submergence assisted by icebergs; and I cannot help suggesting that those geologists who are too experienced in the ways of land-ice and know its capacity too well to believe in the fantastic nonsense that has been written about ice-sheets, have in their despair appealed to an alternative so lacking in empirical support, because they must seize at any straw rather than surrender their fetish of Uniformity.

Another theory to account for the Chalky Clay and its associated deposits was formulated by Carvill Lewis, and it retains a considerable importance since it has received the countenance of at least one prominent English geologist. Lewis formulates his view thus:—(1) "The Hessle Clay is due to a marginal lake. (2) When this marginal lake burst westwards through various channels in the chalk wolds it made an angular, torrential, flinty gravel; the unfossiliferous 'boulder-gravel' or 'cannon-shot' gravel of Cromer and Norwich. (3) Debacles thus flowing into the lower ground on and west of the Chalk wolds, formed a more inland and second series of lakes, which contained a mud filled with chalk; and this is the great Chalky Boulder-clay. (4) This lake in turn filled up and overflowed west and south, past Leicester and Rugby, etc., along the Triassic country, making flinty and chalky gravels, the Northern Drift of the Midland and Southern Counties, which is torrential. (5) Rivers from glaciers at York and in Cheshire joined the flinty streams." ("Glacial Geology of Great Britain," p. 334, note.)

When we read a series of *obiter dicta* like these, stated with the utmost *sang froid*, without the slightest evidence of any kind to support them, and are told this is science, it makes us feel almost

uncomfortable. So far as I know, there is not a single feature of any kind presented by the surface beds of Eastern England which in any way resembles a lake deposit. Nor can I see how any lake could possibly exist in this part of England, on the scale and of the character required to explain the phenomena. If we make a contour map of the area occupied by the Chalky Clay and its associated deposits, and try to realize how by any process the district they occupy could be converted into a lake, we shall indeed be puzzled. Lakes cannot exist without dams or fences to restrain and keep back their watery contents. What and where were the dams in this case? We have shown the impossibility of conceding a solid North Sea to act as a barrier on the east; but even if we could concede it, how is it possible to believe that a lake of open water could exist on the west side of the great icy barrier, when the climatic conditions in the North Sea were such as to be consistent with a solid ice-mass there? But granting such a barrier on the east, what were or could be the barriers of such a lake on the south and west? These barriers must have been stupendous, if we are to account for the Chalky Clay and its associated beds at the various elevations at which they occur. Where is there a trace of anything of the kind? Where, again, are the fresh-water shells, which would certainly be found in large sheets of fresh water, such as this is supposed to have been? Where, in fact, is there any débris of any kind pointing to a fresh-water origin?

What, again, of the contents of the beds themselves? Marly clays, no doubt, are deposited in lakes, the result of deposition from the streams that flow into them, but such clays are arranged in regularly disposed laminæ, and are not heterogeneous masses such as the Chalky Clay is.

Again, this Chalky Clay and the associated gravels and sands could not have originated in the bottom of the lake itself, from the disintegration of its own bed. Lakes do not deepen themselves by a process of disintegration of this kind; they are gradually and continuously being filled up by accumulations. So that these soft beds must have been brought in by streams, but if so, how is it they are not more efficiently sorted? It is true the sands and gravels are separated from the clays, but each of these sets of beds is studded with blocks and boulders, which have only in rare cases come from a distance, and for the most part are derived from the locality, and which under the influence of gravity would have been sorted apart if their portage had been like that of other river-borne materials.

Again, when rivers bear materials into lakes they do not drop them all over the lake-bottom in the irregular fashion we see in these beds. They drop them in a most methodical way by making deltas, which gradually enlarge until they fill up the lake. There are no deltas here, nor anything like deltas.

Where, lastly, are we to get the rivers in the particular area in question whose current and force should be equal to carrying the stones and shingle and gravel, which form such a large proportion of these beds? They must have been torrential rivers with rapid

falls to have done so, but there is no fall, or virtually none, in the rivers of Eastern England; and how could rivers by any process convey into a lake deposits which are distributed, as these surface beds are distributed, over an undulating surface? Rivers cannot run up and down hill, and how could the contents of these beds become mixed in the particular way we find them mixed in a lake? How could rocks from Norway and rocks from Durham be mixed with those from Mount Sorrel and from the wolds of Lincoln and Norfolk? A lake is not a churn, in which the contents are being tossed about and mixed by some uneasy force. A lake is a singularly quiet bourne, in which those objects which are conveyed lie at rest; and the work required in the present case, as we have seen, is the bringing together from the four quarters of heaven of stones and other ballast, mixing them and then distributing them. If this were done by rivers, the rivers must have had the art and capacity of flowing in opposite directions, a postulate which would have staggered even Dr. Croll. The fact is, one can hardly restrain one's patience in having to dissect and show the futility of a theory so void of every rational element as that which attributes the soft deposits of Eastern England to the operations of a lake. It is little short of scientifically criminal for a man with high abilities who has acquired a certain reputation to bewilder and defy the world by throwing down such crudities, as if they settled anything or answered any real questions, and to offer a factitious shield behind which a crowd of thoughtless people, whose science is all deductive, and who never sing solos but only join in a chorus, may take their stand.

The lacustrine theory exhausts the various explanations of the soft beds of Eastern England which involve water operating in its normal methods. If, as I have argued, water is not only capable of explaining the phenomena, but is also alone capable of doing so, it must, therefore, be water acting in quite a different way to its normal methods. It must have been water acting in great masses torrentially, such as was invoked by the Old Masters of Geology, acting in the way, in fact, in which I have invoked it in my "Glacial Nightmare." To this explanation I have seen no reply except a pious exclamation of horror or two at such a daring departure from the pontifical authority of Sir Charles Lyell. This expression of opinion does not affect those who have never worshipped at that shrine, and who believe with Sedgwick and Murchison that the forces which *periodically and continuously* have torn and contorted the crystalline rocks of the Alps, which have tossed the Miocene beds of the Rigi and set them on their edges, and which have done stupendous work of a similar kind in all latitudes and in all geological ages, were not exhausted when we come to the end of the Tertiary period, and were as capable then as they had often been before of crumpling and bending and breaking the earth's crust, in Titanic fashion, and will assuredly repeat their rough work again presently. This now is the real inductive theory of Uniformity, to which the bastard theory of

Uniformity, which claims the manifold rents and twists and contortions of thick beds of hard crystalline rocks, faulted and fissured and fractured as they so often are, as the effects of the repetition of raindrops and the diurnal erosion of river and tide, has no claim.

Those who would concede this, either wholly or in part, as a general conclusion, nevertheless bid me produce direct evidence that such throes and dislocations took place in a period so recent as the Pleistocene. This is not unreasonable, although the men who champion the cause of ice absolutely refuse to explain the competency of ice to do the particular work they attribute to it.

I am now, of course, limiting myself entirely to the problem presented by the surface beds of Eastern England. That problem, as it presents itself elsewhere, I hope on another occasion to face. Now in regard to the area at present under discussion, I have already shown in these pages, by a very considerable accumulation of evidence, that during the Pleistocene period a vast and extraordinary folding, twisting, and breakage of the strata did occur which operated over all the district, so far as we know, occupied by Secondary and Tertiary beds, from the great Chalk escarpment in the west, as far as Denmark and Scania in the east; and this view is supported not only by a heretic like myself, but by highly respected foreign geologists like Koeppen and others. If this be maintainable, then I have surely met the challenge of those who ask for proofs of great dislocations in this area in Pleistocene times. If it be not maintainable, then I should be very grateful indeed to anyone who will answer the arguments I have used, and which have been used by better men than myself, and refute the points I have quoted.

This particular dislocation seems, in the main, in this area to have involved some lateral compression or some east-and-west tellurial wave, by which the beds were thrown into folds ranging north and south, raising a series of round-backed wolds, and causing a corresponding series of deep depressed valleys between them. The extent of these depressions can be measured partly by the depth at which the land is now submerged below the sea-level between England and Denmark, over an area on which the Mammoth and its companions roamed; and, secondly, by the well borings at Yarmouth, Boston, etc., in Eastern England, and by others in Holland, which prove to what a depth below the sea-level the former land surface was lowered at this time. The depression was filled up by drift-beds, all dating from our period. The evidence of these wells seems to me to be crucial and critical.

I have also shown in the same paper that the movement here referred to was not a gradual and continuous movement. I am not a great believer in general movements of the earth's crust over large areas which are gradual and continuous. The earth's crust is not like dough, under the influence of yeast. Its movements, when we can follow them, are generally spasmodic and rapid, and involve breakage and tearing, and the evidence in this case, as I have tried

to show, is consistent only with this conclusion, a view also held by Murchison.

What, then, have we to face? Why, the fact that at the very time when these soft surface beds of Eastern England, which have set the chorus of glacial geologists singing their monotonous melody, were distributed, there was a widespread and tremendous dislocation of the solid crust of the earth over many degrees of longitude, inclusive of the area where these beds occur; a dislocation which was very rapid, if not sudden and cataclysmic. About this I have no doubt whatever. The conclusion seems to me absolutely unanswerable if we are to accept induction as our teacher.

If this be so it is equally certain that such a dislocation, involving a tremendous downthrow of the strata far below the ocean-level over the area now occupied by the southern part of the German Ocean, must inevitably have been accompanied by a tremendous inrush of water on a vast scale from the areas in the north and north-east, where open water then existed from the seas of Scotland and Northumbria, and from the Baltic and its gulfs, thus supplying the very machinery which that famous and most accomplished geologist, Hopkins, a great physicist and mathematician, invoked hypothetically; a postulate which was supported by Whewell, another of the really great men of genius of this century, and accepted by Murchison. "*Fides magister meus.*"

Thus do we answer those who demand whence we would derive those vast waves of translation, whose competency the champions of the current school have not the temerity to question. Waves which would under the circumstances and conditions named literally treat the foreign stones, whose portage causes so much trouble to the glacialist, as a child treats its marbles, would overwhelm the land, irrespective of its contour, as such waves on a smaller scale have done in Japan, mixing the freight they brought from afar with the loamy débris they met with *en route*. These waves take up with their powerful and yet at times gentle hands, as we have seen done in smaller areas, vast masses of solid rock or even of soft débris, and move them from lower to higher levels, padding them round with current bedded sands and concentric laminæ; taking up, as has been done elsewhere, great masses of heterogeneous clays or rough gravels, and throwing them down in heaps when the contour of the country arrested their force, and in other cases, where the waters were not so turbulent, passing over laminated beds with little disturbance, and overlaying them with sands and clays with curved laminæ and layers, as may be seen *in petto* after great storms; in some cases hardly disturbing the sands and gravels already on the ground, in others tossing them about and mixing them with foreign stones, when rushing into a great hollow like the Fens, mixing as in a cauldron the various ingredients they met with, clay and stones of different kinds, and then, as they spread out and spent themselves on the heights above the Thames and the uplands of Warwickshire, spreading a more or less continuous mantle of homogeneous structure, geographically distinguished by the preponderance of

local débris. They would end not as ice-deposited débris could have ended, by a great series of concentric ramparts and moraines, but by the deposit gradually thinning out. As they swept along in places, rough rubble, made of chalky and oolitic fragments, scoring them occasionally, and generally polishing them by rubbing them together as we notice the tide rubs the shingle together when it grates upon our ears, when one great loaded wave after another retires down a shelving slope, and it would not, like ice, carry big stones and little together, but sort them as we find them sorted, the biggest specimens being, in the main, nearest to the parent beds.

As we have seen, the materials were not ready made; the dislocation of the strata provided the local angular rubble; the pebbles, shingles, and sands were already there in the shingle beds and sands of Tertiary age, while the clays were also bare and ready to be churned. It needed only a powerful instrument, powerful and yet light-fingered. Such an instrument is the one I have here quoted, not for the first time. I know of no other capable of doing the work, and for the existence and potency of which there is such a preponderance of evidence, and in the effective phrase of Euclid I would say, until some champion can furnish a better cause, Q.E.D.

I have limited myself in this paper entirely to the deposits of South-Eastern England and the maritime borders of the North Sea on both sides of the water. It is necessary to point out to some English geologists that the phenomenon to be explained is not a parochial one and limited to these islands. The same kind of stones which have come to Britain from the Christiania Fjord have also been found in Holland. The same disturbance and rearrangement of the Crag sands which have caused so much false reasoning in East Anglia have occurred, but on a vastly greater scale, in Holland, where these sands are not only found in greater depths but in the form of the so-called Campinian Sands, distributed over a much wider area, and which no stretch of the imagination could suppose were ice deposits nor the deposits of subglacial streams, since they uniformly mantle whole provinces with more or less homogeneous sands, and gradually thin out. I hope to have more to say to them on another occasion.

At present I would content myself with saying that I hold this inrush of water from the north and north-east to have been the real dynamical cause of the effects which have been so persistently attributed to ice. When this inrush reached the loose sands of the Crag it rearranged them; when it reached the Lincolnshire and Norfolk wolds it passed over them or through their gaps, and took with it the chalky débris which it met on their exposed sides, leaving none on their eastern flanks because there was no débris available there. Thus it laid down chalkless clays and loams on one side of the wolds and chalky ones on the other. The same cause would explain the peculiar distribution of the Mount Sorrel boulders.

The North Sea inrush did not do all the work. It could not and

did not bring the limestone and millstone grits of Derbyshire into Eastern England, nor scatter boulders from Shap over the Yorkshire plain, nor the quartzite pebbles of Warwickshire over a large part of the South-Eastern Counties. These were the effects of separate impulses, which I shall not shrink from discussing on another occasion, but which I do not wish to confuse the present issue with. In one respect only must I say something of them. There is no more treacherous phenomenon in the world for the young geologists than the various mounds, ramparts, etc., of soft materials which occur in certain districts, and which simulate in a measure the external contours of glacial moraines, just as chalk and water so often in London simulate milk. These are generally seized upon greedily as most patent evidences of glacial action, and are at once labelled moraines, and pass as such into the ephemeral textbooks of our science. It is forgotten that by far the greatest number of mounds and ridges now being formed are being formed by the sea or by torrential waters, and wherever two opposing rushes take place it is inevitable that mounds and banks should occur, and the contours of these mounds will depend largely on the rapidity with which they are formed. Now we have in Eastern England examples of such mounds which have been called moraines on the slightest possible grounds, and which I believe to have been the result of the North Sea rush meeting with an impulse from the west or with some obstacle.

Such mounds and ridges occur in one or two isolated places in Eastern England, notably in Hunstanton Park in Norfolk, in Lincolnshire, and in Holderness. They have been treated as glacial moraines; I do not know on what grounds, unless it be on the easy ground that every mound, however formed and whatever it contains, must be a moraine. These particular mounds bear no relation known to me to any possible glaciers, but do bear a very near relation to the mounds and ramps formed by rapid currents converging from different directions upon the same spot.

In regard to the mounds at Hunstanton Mr. Carvill Lewis, a very strong glacialist champion, says :—"I visited the so-called esker in the Park near Hunstanton. I saw in an open field a long hill of gravel resembling a kame in its narrow ridge-like form, but not resembling one in that the characteristic knobs and kettle-holes were absent. . . . . It turned at right angles, and continued as a narrow gravelly ridge in an E. and W. direction for one-third of a mile . . . . it consists, at least in its upper part, of water-worn coarse gravel and sand. This last looked like sea sand, not kame sand. Contortions with a little clay in them were seen in some parts of the cutting. I have never seen such contortions in kames, although they are common in marine drifts. Finally, in the sand I found many fragments of marine shells. Shells never occur in kames, and he concludes that the mound is not a kame but a portion of an old sea-beach. It is close to the sea, only 50 feet above it, and bends in an arch quite unlike a kame, but just as a beach might, keeping parallel to the present sea-beach. One part is parallel to the Wash, another part to the sea, and it stands just on the point between the

two. *Possibly it was caused by the two currents, one of the Wash, the other of the open sea.* It is clearly marine, like the gravels of the neighbourhood. Is it a dune? or a bar? or a bank?" ("Glacial Geology of Great Britain," pp. 340–1.)

The same writer refers to a curious ridge of Boulder-clay extending from Slickney through Sibsey in Lincolnshire, and significantly adds: "This is a shoal or bar" (id., p. 333). Again, he says:—"Above Louth is a very low flat ridge of local character parallel to the chalk cliff, but a quarter of a mile east of it, made of Hessle Clay. *It has none of the characters of a moraine, but has the shape of a subaqueous sand bar or mud tank*" (id., p. 235). I hold that the same arguments apply to the mounds and ramparts of Eastern Yorkshire which have been so readily accepted as moraines by writers who see ice everywhere, and I prefer to strengthen my view by a quotation or two from the writer last named, who is so often frank where frankness is much needed. He is disposed to treat some of the mounds as morainic, but has to confess that those near Gristhorpe are rounded in outline as if either made in water or subsequently submerged (id., p. 206). In regard to the hummocks between Breckton and Speeton, he associates them with the similar ones in Holderness which contain shells and shell fragments, showing, as he says, "that if it is a moraine it was made under water," while the fauna is much less Arctic in character than in the Bridlington Crag beds. Where shells do not occur the beds in these mounds are sorted into sands and clays and gravels, and rudely stratified conditions quite inconsistent with true moraines, which consist of heterogeneous "muck."

The laminated clays and the sifted sands in these mounds are assuredly conclusive evidence that they were made by water and nothing else. The fact is, glacialist champions are content merely to note the existence of mounds somewhat resembling in their outward contours those left by glaciers, and forget that water deposits similar mounds; and in order to test whether they are moraines or not we must make sections in them and see whether traces of stratification and sifting are to be found. In regard to the mounds and so-called eskers of Eastern England, those I have seen bear the inevitable impress of having resulted from contending currents of water, sometimes rushing at a rapid pace and sometimes retreating, and are in no sense moraines at all. The best proof that they are not moraines is to be derived probably from the corresponding Flemish deposits. There we should expect to see these mounds repeated on a great scale if they were moraines, for the country is flat and uniform in outline, but instead of this we have a uniform mantle of gradually thinning-out sands. This thinning out, again, is quite contrary to all the analogies of glacier deposits, which are deepest at the foot of the glacier, and, like the similar thinning out of the Chalky Clay and the gradual diminution of the size of the boulders as we depart from the centre of distribution, is only consistent with a widely extended tumultuous current. Such a current, or rather a series of currents, has, in fact, been postulated by the extreme

glacialists to account for the distribution of the English so-called glacial gravels; or, rather, by those glacialists who realize that gravels can only be moved by torrential waters, and that rivers do not run up and down hills and lay down gravel on the hill-tops as well as the valley-bottoms. Thus, Lewis attributes the distribution of the so-called cannon-shot gravel to the action of a powerful current, and he quotes the apposite fact in proof of it that the stones frequently have their longer axes vertical and the flints are often quite unworn; and he accounts for the flinty gravels of the Midlands by the bursting of a series of lakes, thus causing a number of debacles (op. cit., p. 234).

How ready these champions of Uniformity are to go to Saturn for their unproved, untested, and absolutely hypothetical machinery! Another feature of the drift-beds has also, in my humble view, been distorted to prove a quite preposterous position by the orthodox geologists. Because valleys very often have their flanks fringed by so-called glacial beds, it has been argued that they were once entirely filled up with this material, and that all of it has been removed by subsequent denudation, leaving only these marginal beds. How this denudation was brought about in a district where no denudation whatever, or virtually none, now takes place, where every stream is raising its own bed, and where the materials of this portentous denudation were carried to, we are not told. The fact is, that the phenomena in question are the most patent evidence of a great rush of waters which scoured the valley bottoms, but left a marginal terrace or series of terraces of débris just as every flood does, and swept along the greater part of its load, choked and jammed the greater part of it in the upper reaches of the valleys. The theory that these valleys have been cut down or carved out of the so-called glacial beds is absolutely at issue with every serious fact except the most superficial one, and has entirely reversed the course of geological reasoning on the subject.

From every point of view, therefore, I claim to have shown that the old geologists are right and that the new ones are wrong on this issue, and that it was water and not ice which laid down the surface beds and gave a final contour to the surface of Eastern England and of Holland.

In disputing, as I have so persistently done, the extravagant claims of the glacialists, I have really done so in the interests of a rational uniformity. I do not doubt that in former days the mountains of Scotland, Cumberland, and Wales may have nursed glaciers, and that these glaciers could do and did similar work to modern glaciers. What I deny is the potency of those glaciers to distribute the result of their handiwork over the flat lands of Eastern England. I also deny the capacity of ice to travel over hundreds of miles of level or undulating country from Scandinavia to the Carpathians and to Norfolk, and to perform work contrary to the proved capacity and nature of ice. I affirm that the geological facts refuse to be correlated with such a hypothesis, but everywhere speak of a great diluvial movement.

VI.—On the Microscopic Contents of a Sample of Bracklesham Clay from Lee-on-Solent, Hampshire.

By Frederick Chapman, A.L.S., F.R.M.S.

In 1862, Professor T. Rupert Jones published some notes on a careful microscopical examination of five samples of clay from the Bracklesham beds of Bracklesham, Selsea, and the Isle of Wight (?).[1] This paper gave a good idea of the systematic methods which could be employed in working over a sample of fossiliferous material, especially when rich in microzoa, and the results of which are often of great use to geologists and palæontologists.

Upon the lines there laid down, the following study of a sample of clay from Lee-on-Solent has been made at the request of Professor Rupert Jones; and he has further kindly suggested that, since the microzoa have had much attention directed towards them of late years, these notes are worth publication, for further reference in connection with beds of the same age from other localities.

The bed from which the sample of clay was collected[2] lies about 250 yards west of Lee Pier.[3] It crops up out on the beach-level. The cliff at this spot is capped with drift, composed of flint, chert, and quartz. Beneath this is a bed of sand, and this is immediately underlain by the fossiliferous Bracklesham bed; but of this there is very little exposure.

Results of the Examination of a piece of Bracklesham Clay, weighing 480 *grains.*

A dark-green sandy (glauconitic) clay.

	Argillaceous.	Arenaceous.	Calcareous.
Total of 480 grains, separated as follows	280 grains	135 grains	65 grains
Approximate percentage of constituents	58·3	28·1	13·54

Mineral Constituents observed in the fine sandy residue after washing.—Quartz, Tourmaline, Zircon, Rutile, Glauconite.

Organic Remains.

Pisces. *Lamna* (?), fragment of tooth.

Gasteropoda. *Solarium canaliculatum*, Lamarck, one specimen; *Pleurotoma callifera*, Edwards, one specimen.

Lamellibranchiata. *Crassatella Bartonensis*, Edwards, one specimen; *Corbula pisum*, Sowerby, common.

Bryozoa. *Orbitulifera petiolus* (Lonsdale), very common.

Ostracoda. *Bairdia contracta*, Jones, very rare; *Cythere striato-punctata*, Jones, very common; *C. scabropapulosa*, Jones, frequent; *Cytheridea perforata* (Römer), rare; *C. Muelleri* (Münster), very

[1] "On the Microscopical Examination of some Bracklesham Beds": The Geologist, February, 1862, pp. 59–63.

[2] I am indebted to the Rev. R. Ashington Bullen, B.A., F.G.S., of Reigate, for the fossiliferous clay from Lee-on-Solent; and he has also kindly furnished me with the notes on the position of the beds in the locality, as given above.

[3] Lee-on-Solent, formerly Stubbington.

rare; *Krithe Bartonensis* (Jones), very rare; *Cytherella Dixoni*, Jones and Sherborn, very rare; *C. compressa* (Münster), rare; *C. Beyrichi* (Reuss), rare; *C. Reussi*, Jones and Sherborn, rare.

Cœlenterata *Turbinolia humilis*, Milne Edwards and Haime,[1] two specimens.

Foraminifera. *Miliolina trigonula* (Lamarck), very rare; *M. Schreibersii* (D'Orbigny), very rare; *Haplophragmium foliaceum*, Brady, rare; *Polymorphina gibba*, D'Orbigny, very rare; *P. lactea*, Walker and Jacob, very rare; *Nummulites variolaria* (Lamarck), excessively common.

NOTICES OF MEMOIRS.

I. — Marine Organisms and the Conditions of their Environment. By Dr. John Murray, F.R.S.[2]

THE ocean may be divided into two great biological regions, namely, the superficial region, including the waters between the surface and a depth of about 100 fathoms, and the deep-sea region, extending from the 100 fathoms line down to the greatest depths. The superficial region may be subdivided into two provinces, the shallow-water or neritic province around the land masses where the depth is less than 100 fathoms, and the pelagic province, embracing the superficial waters of the ocean basins outside the 100 fathoms line; these two provinces contrast sharply as regards physical conditions, which are of great variety in the neritic province, and very uniform over wide areas in the pelagic province.

Temperature is a more important factor in determining the distribution of marine organisms, mostly cold-blooded, than in the case of terrestrial species, mostly warm-blooded and air-breathing animals, the distribution of which depends rather upon topographical features than upon climatic conditions.

The pelagic tropical waters of the ocean teem with various forms of life, of which probably 70 to 80 per cent. are plants, converting, under the influence of sunlight, the inorganic constituents of sea-water into organic compounds, thus forming the original source of food of marine animals both at the surface and at the bottom of the sea.

The number of species living in the pelagic waters of the tropics may greatly exceed the number in polar waters, where, on the other hand, there is often a great development of individuals, so that there is probably a greater bulk of organic matter in the cold polar waters than in the warm tropical waters. The rate of animal metabolism is slower at a low than at a high temperature, and organisms inhabiting tropical waters probably pass through their life-history much more rapidly than similar organisms living in polar regions. Carbonate-of-lime-secreting organisms are most

[1] Previously recorded from the Barton beds of Hampshire.

[2] An Address delivered at the Royal Institution.

abundant in the warm tropical waters, decreasing in numbers towards the polar regions, and it has been shown that the precipitation of carbonate of lime from solution in sea-water takes place much more rapidly at a high temperature. The pelagic larvæ of bottom-living species are always present in the warm surface waters of the tropics, sometimes growing to an enormous size; but they are absent from the cold polar waters and in the deep sea, where the majority of the bottom-living species have a direct development.

The Arctic fauna and flora, both at the surface and at the bottom, resemble the Antarctic fauna and flora, and a large number of identical and closely related species are recorded from the two polar areas, though quite unknown in the intervening tropical zone.

The boundary-line between the deep-sea region and the neritic province is marked out by what has been called the "mud-line," where the minute organic and inorganic particles derived from the land and surface waters find a resting-place upon the bottom, or serve as food for enormous numbers of crustacea, which in their turn are the prey of fishes and the higher animals; this mud-line, in fact, appears to be the great feeding-ground in the ocean, and its average depth is about 100 fathoms along the borders of the great ocean basins.

The majority of deep-sea species are mud-eaters; some are of gigantic size; some are armed with peculiar tactile, prehensile, and alluring organs; some are totally blind, whilst others have large eyes and are provided with a kind of dark lantern for the emission of phosphorescent light. The deep-sea fauna does not represent the remnants of very ancient faunas, but has rather been the result of migrations from the region of the mud-line in relatively recent geological times.

The "Challenger" investigations show that species are most abundant in the shallow waters near land, decreasing in numbers with increasing depth, and especially with increasing distance from continental land.[1] This is true as a general rule, especially of tropical waters, but in polar regions there are indications of a more abundant fauna in depths of 50 to 150 fathoms than in shallower water under 50 fathoms.[2]

The various points touched upon regarding the distribution of marine organisms, might be explained on the hypothesis that in early geological times there was a nearly uniform high temperature over the whole surface of the globe, and a nearly uniformly distributed fauna and flora; and that with the gradual cooling at the poles, species with pelagic larvæ were exterminated or forced to migrate towards the tropics, while the great majority of the species which were able to survive in the polar areas were those inhabiting

[1] See 'Challenger' Reports, "A Summary of the Scientific Results," by John Murray, pp. 1430–6, 1895.

[2] See Murray, "On the Deep and Shallow-water Marine Fauna of the Kerguelen Region of the Great Southern Ocean": Trans. Roy. Soc. Edin., vol. xxxviii, p. 343, 1896.

the mud-line. The uniform physical conditions here referred to might be explained by adopting the views of Blandet[1] as to the greater size and nebulous character of the sun in the earlier ages of the earth's history.—*Nature*, March 25, 1897.

II.—The Palæolithic Deposits at Hitchin and their Relation to the Glacial Epoch.[2] By Clement Reid, F.L.S., F.G.S., of the Geological Survey of the United Kingdom.

CERTAIN excavations and borings at Hoxne, undertaken in the year 1896 at the cost of the British Association and of the Royal Society, threw much light on the relation of Palæolithic man to the Glacial Epoch.[3] It was thought advisable therefore to examine the similar deposits at Hitchin, to ascertain to what extent the conclusions already arrived at were supported by exploration at a fresh locality; and the cost of these investigations was defrayed by the Council of the Royal Society.

Palæolithic implements have long been known from Hitchin, and their position in and at the base of a stony brickearth was well ascertained. It was also known that this brickearth rested on loam and shell marl, with fresh-water mollusca and mammalian remains. All this had been made perfectly clear, principally by the researches of Prestwich, Sir John Evans, Mr. W. Ransom, and Mr. William Hill. The most important of the doubtful points were the relations of these ancient alluvia to the widespread sheet of Chalky Boulder-clay and to the valleys of the existing streams.

A preliminary examination of the neighbourhood of Hitchin convinced the author that the Palæolithic and ancient alluvial deposits of Hitchin occupied a small irregular valley, which had become silted up and almost obliterated. Attention was therefore mainly devoted to the search for Boulder-clay beneath the Palæolithic loams, and to the sinking of a trial-pit and bore at the point where the buried valley appeared to be deepest.

This exploration tended to show that the story told by the old valley at Hoxne was repeated at Hitchin. Indeed, the succession of events at the two localities was so similar as to leave scarcely a doubt that there was an equivalent set of strata, although unfortunately the series was less perfect, and the gaps discovered at Hoxne are still unbridged by any records yet found at Hitchin. Hitchin yields strong corroborative evidence in favour of the conclusions arrived at in the Hoxne Report, and adds somewhat to our knowledge of the temperate flora of the ancient alluvial strata lying between the Chalky Boulder-clay and the Palæolithic brickearth.

Hitchin lies in the valley cut by the Hiz, a small stream which rises within a mile of the town. Chalk is seen in the valleys, and rises irregularly through the thick sheet of drift that masks most of the area. The greater part of this drift consists of coarse

[1] Bull. Soc. géol. France, sér. 2, t. xxv, p. 777, 1868.
[2] Abridged from the Proc. Royal Society, vol. lxi, pp. 40–49, March, 1897.
[3] Rep. Brit. Assoc. 1896, p. 400.

flint-gravel, partly of Glacial, partly of Palæolithic age; and one of the greatest difficulties met with is the impossibility of deciding whether any particular pit is in Glacial or in Post-Glacial gravel, and whether the gravel passes under or over the Chalky Boulder-clay. The material being used again and again, the composition of the gravel is practically the same in each case, except for the occurrence of implements in the newer one.

The first thing to be done was to ascertain whether the Chalky Boulder-clay, an undoubted glacial deposit, passes under or over the Palæolithic brickearth. With this object, borings were made in the pits out of which implements have been dug. The author gives details of these borings, the results of which may be shortly summarized thus:—In Ransom's (New) Brickyard, after penetrating the Palæolithic brickearth and underlying fluviatile loam to a depth of 60 feet, some blue chalky clay was penetrated in Bore Hole No. 2, and in BH 1 derivative fossils from the Boulder-clay were obtained at about the same level in the lower part of the old alluvium. In each case boring was stopped by gravelly sand full of water. Other borings in Jeeves' Yard and in some old brick-pits on Maydencroft Farm yielded no trace of Boulder-clay. One only (BH 12) passed through undoubted Boulder-clay. The section is—

		feet.
Palæolithic.	Yellow brickearth and small stones ... ... { dug / bored	9 / 5½
Ancient alluvium	Yellow and white marl and silt	2
	Yellow loam and small chalk pebbles	½
	Chalky Boulder-clay	9
	Loamy chalky gravel (base of the Boulder-clay)	2
	Gravelly sand (boring stopped by large stones)	8
		36

The site of this boring is close to the western margin of the old channel, Chalk appearing at the surface within a short distance. The occurrence of the Chalky Boulder-clay at this spot at a high level, and its absence, or representation by derivative material, at lower levels in borings made nearer to the centre of the channel, suggest that the channel was, to a large extent, excavated, or re-excavated, after the deposition of the Boulder-clay, as was the case at Hoxne.

The course of the ancient silted-up channel cannot yet be defined. Loam with Palæolithic implements occupies a belt extending for about a mile south of Hitchin.

The underlying river alluvium is entirely overlapped and hidden by the Palæolithic brickearth, and is only to be seen where the brickearth has been dug away. It is found in Ransom's and Jeeves' brickyards, and it has now been discovered half a mile to the SSW., in two borings on Maydencroft Farm. It apparently occupies a narrow belt in the middle of the old valley. The greatest depth of this valley could not be proved, owing to the running sand and gravel, which made boring so difficult. The bottom lies at least as low as the level of the existing valleys

of the Hiz and Purwell, for five different borings were abandoned at about that level, without having reached Chalk. The trend of the buried channel seems to be from south to north, in this following the general slope of the ground and running parallel to the course of the existing streams.

The relation of the Boulder-clay to the alluvial deposits having been settled, attention was devoted to an attempt to penetrate to the bottom of the valley in its deepest part. A trial-pit was sunk in Ransom's old brickyard, within a few yards of the spot where a pit had been sunk by Messrs. Prestwich and Evans about 1879. In this brickyard a large number of implements had been obtained from the irregular gravelly base of the brickearth, where it rests on the older alluvial deposits. The newer brickearth, here about 24 feet thick, had been already entirely removed at the spot where the trial-pit was sunk. After sinking 14 feet through brown bedded carbonaceous loam, full of badly preserved shells and plant-remains, boring tools were used, and a further depth of 17½ feet of alluvial loam was penetrated before the gravelly sand below was reached. At the base of the alluvium was found a foot or so of hard black loam with fresh-water shells and fragments of Jurassic fossils derived from the Boulder-clay.

In working out the material afterwards, it became evident that from top to bottom the alluvial deposits below the Palæolithic brickearth belonged to one series, the same plants occurring throughout. Hence there were only two deposits to deal with—a stony brickearth yielding little or nothing but Palæolithic implements, and a series of ancient alluvial deposits below, full of plants and shells, but, as far as known, without trace of man. The mammalian remains were all said to come from the whitish marly silt which occurs locally immediately below the Palæolithic brickearth. They are mostly in Mr. W. Ransom's collection, and were determined by Mr. Sanford. The remainder of the animals and plants, with the exception of two species of mollusca, were obtained in the trial-pit just described. For the determination of the fishes, the author was indebted to Mr. E. T. Newton, and for the mosses to Mr. W. Mitten; the mollusca and flowering plants were identified by Mr. Reid himself.

Mammals.—*Ursus; Equus caballus*, Linn.; *Rhinoceros; Hippopotamus* (a waterworn bone); *Cervus elaphus*, Linn.; *Elephas primigenius*, Blumb.

Fishes.—*Perca fluviatilis*, Linn.; *Esox lucius*, Linn.; *Leuciscus rutilus*, Linn.; *Leuciscus erythrophthalmus*, Linn.; *Tinca vulgaris*, Cuv.

Insects.—Elytra of several genera of beetles, badly preserved; Galls.

Mollusca.—*Helix pulchella*, Müller; *Clausilia biplicata*, Mont.; *Carychium minimum*, Müller; *Planorbis albus*, Müller; *Planorbis carinatus*, Müller (recorded by Mr. E. T. Newton); *Planorbis complanatus*, Linn.; *Planorbis nautileus*, Linn.; *Planorbis nitidus*, Müller; *Planorbis spirorbis*, Müller (found by Mr. A. S. Kennard); *Limnæa auricularia*, Linn.; *Limnæa peregra*, Müller; *Limnæa stagnalis*, Linn.;

Velletia lacustris, Linn.; *Valvata piscinalis*, Müller: *Valvata cristata*, Müller; *Bythinia Leachii*, Shepp.; *Bythinia tentaculata*, Linn.; *Pisidium pusillum*, Gmel.; *Sphærium corneum*, Linn.; *Anodonta*.

Flowering Plants.—*Ranunculus aquatilis*, Linn.; *Ranunculus sceleratus*, Linn.; *Ranunculus repens*, Linn.; *Montia fontana*, Linn.; *Prunus spinosa*, Linn.; *Poterium officinale*, Hook. f.; *Pyrus torminalis*? Ehrh. (identical with seeds found at Hoxne); *Hippuris vulgaris*, Linn.; *Myriophyllum*; *Cornus sanguinea*, Linn.; *Sambucus nigra*, Linn.; *Eupatorium cannabinum*, Linn.; *Fraxinus excelsior*, Linn.; *Menyanthes trifoliata*, Linn.; *Lycopus Europæus*, Linn.: *Ajuga reptans*, Linn.; *Alnus glutinosa*, Linn.; *Quercus robur*, Linn.; *Ceratophyllum demersum*, Linn.; *Sparganium*; *Potamogeton crispus*, Linn.; *Potamogeton*, sp.; *Potamogeton*, sp.; *Naias marina*, Linn.; *Scirpus lacustris*, Linn.; *Scirpus*, sp.; *Carex*.

Mosses.—*Antitrichia curtipendula*, Brid.; *Homalothecium sericeum*, Bry. Europ.; *Hypocomium brevirostre*? Bry. Europ.; *Isothecium*?; *Neckera complanata*, Bry. Europ.; *Stereodon cupressiformis*, Brid.; *Zygodon*?

Characæ.—Several species indet.

Such trees as the oak, ash, sloe, cornel, elder, and alder point unmistakably to a temperate climate, and the fauna and flora as a whole suggest climatic conditions not differing greatly from those we now enjoy. Mr. Mitten writes of the mosses, that "all these are inhabitants of a sylvan temperate region . . . . . and none point to a different environment from that now existing; they are not Arctic." The occurrence of *Naias marina*, now only found in Britain in two of the Norfolk Broads, is singular, although the plant was evidently more common in former times than at the present day. It has now been discovered in the Pre-Glacial deposits of Norfolk and Suffolk, beneath Palæolithic remains at Hitchin, and in a submerged land-surface of Neolithic date at Barry Docks, in South Wales.

The resemblance of the Hitchin Palæolithic brickearth to the Palæolithic brickearth of Hoxne, and the similarity of the old alluvia beneath, both in fossil contents and in the physical changes they suggest, are so striking that one is compelled to correlate them bed by bed. If, however, this correlation be correct, it is evident that the intermediate deposit full of leaves of Arctic willows, so conspicuous over part of the area at Hoxne, is missing at Hitchin. At each locality the same story is told. Some time after the passing away of the ice the land stood higher than now, so that the streams had a greater fall and valleys were cut to a somewhat greater depth. Then the land sank and the valleys became silted up with layer after layer of alluvium, to a depth of at least 30 feet, the climate remaining temperate. The next stage, when an Arctic flora reappeared, is only represented at Hoxne. The third stage in the infilling of the valleys is shown in the curious unstratified decalcified brickearth with scattered stones and Palæolithic implements, identical in character at Hitchin, Hoxne, Fisherton, and other localities, which irresistibly suggest a mingling of wind-transported material and rainwash.

It may be pointed out that if this hypothesis of the origin of the Palæolithic brickearths during the reign of "steppe" conditions be accepted, it will account for the non-correspondence of the ancient channels with the present valleys, a thing very difficult to explain if the infilling were caused by ordinary fluviatile action. If the Palæolithic brickearth be equivalent to the Palæolithic loess of the ancient deserts in Central Europe, it can be understood how during this period of cold drought the smaller streams ceased to flow and their valleys became so filled with rainwash and dust that when a moister climate recurred the streams had to seek new channels.

REVIEWS.

I.—Annual Report of the Geological Survey of the United Kingdom, and of the Museum of Practical Geology, for the Year 1896. By Sir Archibald Geikie, D.C.L., F.R.S., Director-General. 8vo. (London: Eyre & Spottiswoode, 1897.)

THE Annual Report of the Director-General of the Geological Survey since 1892 has contained particulars of the scientific and practical results obtained during the progress of the field-work, and by the officers of the palæontological and petrographical departments. Hitherto, however, the Report has been published only in the more bulky Report of the Department of Science and Art; and although reprints of the portion relating to the Geological Survey have been distributed, they could not be purchased separately by the general public. A new departure has now been made, and the present Report is published at the price of 6*d.*, and in advance of the larger departmental volume.

Occupying 107 pages of closely printed matter, this Report needs the index which has been added to it. A considerable amount of detail relating to all branches of geology, but more particularly to petrographical researches on the ancient schists, and on various other metamorphic and igneous rocks, will be found. Nearly all formations from those of Pre-Cambrian age to the Recent are dealt with, and some facts relating to the Antiquity of Man, to Lake Basins, and other controverted subjects, are included. The Report being in itself a summary of the observations made by the officers engaged on the Geological Survey, it is impossible here to do more than call attention to the publication, which will doubtless find its way into the hands of all working geologists.

II.—Catalogue des Bibliographies Géologiques. Par Emm. de Margerie. 8vo; pp. xx, 733. (Paris, 1896. Issued April, 1897.)

THIS Bibliography of Geological Bibliographies is probably the most valuable and useful work that has been issued under the auspices of the "Congrès Géologique International." It contains 3,918 references to lists and catalogues of papers, to papers and memoirs containing copious references to geological literature, and to memoirs and obituary notices of geologists all over the world.

There are indices to authors, principal subjects, and places. If, however, we want a reference to a memoir, say of Wm. Smith, we must search for it under "Biographies de Géologues—Anglais," in the table or index of principal subjects. If we want a list of works on the geology of Lancashire, we must turn to references under "Grande-Bretagne" in the "Table Géographique." The list of authors is no doubt useful, but we think it would have been much more advantageous to index the Memoir of Wm. Smith under Smith than under John Phillips; and the list of papers on Lancashire, under Lancashire, rather than under Whitaker and Tiddeman. For ready reference we want, in fact, fuller indices to subjects and places. It is, however, ungracious to find fault with a work that in all other respects is full and accurate. Geologists will do well to turn over the pages of this volume and take note of the books and memoirs that relate to their special subjects of study, and many will be surprised to find how much useful bibliographic work has been done. Of such work no example will probably be more used than the volume before us, and all geologists will feel indebted to M. de Margerie for the great care and labour he has bestowed on the Catalogue.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—March 24, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read :—

1. "Notes on some Volcanic and other Rocks which occur near the Baluchistan-Afghan Frontier, between Chaman and Persia." By Lieut.-General C. A. McMahon, V.P.G.S., and Captain A. H. McMahon, C.I.E.

In the first part of this paper Captain McMahon describes briefly the physical geography of the Baluchistan deserts, which extend along the south of the Helmund River, between Quetta and Persia. Taking first the plains and their drainage-system, he shows how the wide alluvial plains of Shorawak and Chagai were probably in earlier times one large lake. North and west of these plains, as far as Persia, lie vast deserts of sand, which in places are gradually encroaching upon and burying the mountain-ranges which rise up like islands in the desert. He shows how the sand has intercepted all the drainage from the mountains and prevented it from making its way, as it would otherwise do, into the Helmund River and the God-i-Zirreh Lake. Turning next to the mountains, Capt. McMahon describes a well-defined line of fault, which he traced for a distance of about 120 miles from north of Chaman, along the Khwaja Amran and Sarlat mountain-ranges to Nushki. East of this fault all the rocks appear to be sedimentary; while those to the west are all, with few exceptions, volcanic and igneous.

The mountain-ranges in the desert described appear to be all volcanic, and reference is made to the Koh-i-Taftan, 12,600 feet high, lying south-west of them, which is still an active volcano.

The curious, grotesquely-shaped peaks of the Koh-i-Sultan range are then briefly described, and especially that named Neza-i-Sultan —a gigantic natural pillar of volcanic agglomerate many hundreds of feet high.

After thus describing the general character of the country, Captain McMahon points out the very remarkable force and activity with which certain natural agents are at present at work there— namely, water, wind, sand, and extremes of heat and cold.

In the second part of the paper General McMahon describes the microscopical characters of the rocks, which consist of lavas, ashes, pumice, igneous intrusive, and sedimentary rocks. The localities in which ores of lead and copper, gypsum, sulphur, etc., occur abundantly are also mentioned.

Some andesites are described, which are especially interesting from a petrological point of view. Rosenbusch mentions that a brown hornblende occurs in some rocks in which the angle of extinction varies from small to *nil*. Some of the andesites described abound in amphibole, red-brown in transmitted light, which possesses the optical properties and specific gravity of anthophyllite, and which uniformly exhibits straight extinction. It is an original and not a secondary mineral.

These anthophyllite-bearing augite-andesites also contain olivine —a mineral rare, but not unknown, in this class of rocks.

2. "On the Association of *Sigillaria* and *Glossopteris* in South Africa." By A. C. Seward, Esq., M.A., F.G.S., University Lecturer in Botany, Cambridge.

In this paper the author describes in detail several specimens of fossil plants submitted to him by Mr. David Draper, of Johannesburg. His conclusions as to the geological age of the plant-bearing beds differ from those arrived at by Mr. Draper from stratigraphical evidence; the plants point to an horizon which may be referred to what is now termed the Permo-Carboniferous age. The difficulty of distinguishing between various forms of *Glossopteris*-leaves is discussed at some length; and the opinion expressed that it is practically impossible to separate the Indian, Australian, and African forms of *G. Browniana*, *G. indica*, and others. The chief interest as regards the plants centres round the specimens of *Sigillaria*; these are fairly well preserved impressions, and are referred to the well-known species, *S. Brardi*. In addition to various forms of the genus *Glossopteris* and the specimens of *Sigillaria*, the following plants are recorded:—*Noeggerathiopsis Hislopi*, *Gangamopteris cyclopteroides*, *Phyllotheca*, *Conites* sp., *Cardiocarpus* sp., and *Sphenopteris* sp.

The paper concludes with some general remarks on botanical provinces in the Northern and Southern Hemispheres, and the relation of the *Glossopteris*-flora to the Coal-measure vegetation of Europe.

3. "Notes on the Occurrence of *Sigillaria*, *Glossopteris*, and other Plant-remains in the Triassic Rocks of South Africa." By David Draper, Esq., F.G.S.

The author gives a brief description of the geology of four localities, within a comparatively short distance from Johannesburg, from which several fossil plants have recently been obtained. He considers the plant-bearing beds to belong to the Lower Stormberg Series of Dunn, and to the horizon known as the Molteno Beds. The most important locality described in these notes is that of Vereeniging, 30 miles south of Johannesburg, where the author found several specimens of *Sigillaria* associated with *Glossopteris* and other plants in iron-stained sandstones. The significance of this discovery of *Sigillaria* is briefly discussed. The several species of plants have been described by Mr. A. C. Seward in a paper recently sent to the Society.

II.—April 7, 1897.—Dr. Henry Hicks, F.R.S., the President, left the Chair, which was taken by Prof. Bonney, D.Sc., F.R.S., V.P.G.S. The following communications were read :—

1. "On the Morte Slates and Associated Beds in North Devon and West Somerset.—Part II." By Henry Hicks, M.D., F.R.S., P.G.S. With Descriptions of the Fossils by the Rev. G. F. Whidborne, M.A., F.G.S.

In the first part of this paper, read by the author before the Society in February, 1896, he described the Morte Slates as they occur in North Devon, and the fossils found in them. In this, the second part, he refers mainly to the rocks classified as Morte Slates in West Somerset He shows that the latter differ in some important characters from those in North Devon, and have an entirely distinct fauna. The fossils obtained from North Devon show that there the beds must in the main be classed with the Silurian rocks; but in West Somerset, so far as discoveries have yet been made, the fossils indicate that they should be classed with Lower Devonian rocks. The author's contention that the Morte Slates which extend through the centre of North Devon and West Somerset from Morte Point to the north of Wiveliscombe, a length of about 40 miles, are the oldest rocks in the area and form an axis with newer rocks lying to the north and to the south, is therefore fully proved by stratigraphical and palæontological evidence. The fossils are carefully described by Mr. Whidborne, and he shows that there are numerous forms in common between them and those considered to be characteristic of the Lower Devonian rocks in the continent of Europe and in America.

The President then resumed the Chair.

2. "The Glacio-Marine Drift of the Vale of Clwyd." By T. Mellard Reade, Esq., C.E., F.G.S.

The local drift of the higher parts of the Vale of Clwyd is replaced by marine drift towards the mouth; and it is the object of this paper to give the results of a detailed examination of these marine drifts, rather than to explain the phenomena. The first part of the paper gives the results of an examination of the Boulder-clay from Craig, west of Llandulas, to the Vale of Clwyd, south-east of Abergele.

Mechanical analyses of the clays are given; but the point of greatest interest is the occurrence of abundance of Foraminifera, especially in the plastic brown and red Boulder-clays, which often contain intensely striated erratics. These Foraminifera have been examined by Mr. Joseph Wright. Most of them occur in the Boulder-clays of Crosby and Wirral; but some of them are very rare in British localities other than those now recorded, namely, *Rhabdogonium tricarinatum*, *Sphecoidina bulloides*, *Pullenia sphæroides*, and *Pulvinulina Menardii*.

The glacial sands and gravels of the east side of the Vale of Clwyd are also described, and especial attention is called to an esker-like mound of sand (gravel), occurring south-east of Diserth Castle, formed of bedded deposits, the bedding of which generally follows the outer form of the ridge. The ridge has Boulder-clay upon the flanks, and is described as rising through the Boulder-clay.

III.—April 28, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "On the Origin of some of the Gneisses of Anglesey." By Charles Callaway, M.A., D.Sc., F.G.S.

The author still maintains the occurrence of two Pre-Cambrian groups in Anglesey, the latter of Pebidian age. In the present paper a description is given of the production of gneissic structure in the rocks of the earlier group occurring in the south of the island. The products of metamorphism are similar to those described by the author in the Malvern area. (i) Simple schists, granite is converted into mica-gneiss, diorite into hornblendic or chloritic gneiss, and felsite into mica-schist; (ii) Injection-schists. In Anglesey felsite plays the part which is taken by granite at Malvern, and certain important differences arise. Gneiss of primary injection is formed by the parallel veining of felsite and diorite, and the author describes cases; he also notices the occurrence of metamorphosed diorite-blocks in grey gneiss, which afford evidence of its eruptive origin. Gneiss of secondary injection is well seen in the Llangaffo cutting, and is explained in a manner similar to that given for an infiltration-gneiss at Malvern, felsite being substituted for granite. The infiltration-products are mainly chlorite, iron-oxide, and epidote, and out of the chlorite, with the addition of materials from the felsite, black mica has sometimes been constructed. The changes have occurred along planes of discontinuity formed subsequently to the consolidation of the rocks.

2. "Note on a Portion of the Nubian Desert South-East of Korosko." By Captain H. G. Lyons, R.E. F.G.S. With notes on the Petrology by Miss C. A. Raisin, B.Sc. (Communicated by Professor Bonney, D.Sc., F.R.S., V.P.G.S.) And Water-Analyses by Miss E. Aston, B.Sc. (Idem.)

A general description of the physical structure of the area, which consists mainly of Nubian Sandstone and crystalline rocks, is given. Coming from Korosko to the Murrat Wells, the crystalline rocks are first met with on the east side of Jebel Raft. The strike of these

is north and south, whilst to the south of the hill the strike is a few degrees on either side of east and west. At Wadi dur Nabadi are ancient gold-workings, indicated by M. de Bellefonds on his map of the Etbai. The crystalline rocks are both massive and schistose. On the crystalline mass of Jebel Raft, and apparently overlain by the Nubian Sandstone, is a very coarse conglomerate containing fragments of crystalline rock, which appears to be older than the Nubian Sandstone.

The Nubian Sandstone has little or no dip, and shows very slight variation in composition. The water-supply of the Nubian Desert is directly dependent on the rainfall, which is very irregular. The wells are sunk in the detritus of the valleys, and contain a large amount of mineral matter in solution, which renders them almost undrinkable; whilst the second source of supply—the rain-water reservoirs—are deep holes in the ravines which intersect the crystalline hills. These holes must be attributed to water-action; and in the reservoir of Medina in Jebel Raft the spherical stones which assisted in forming the pothole still occur. The author believes that these ravines and reservoirs were formed at an earlier period than the present, when the rainfall was heavier.

Miss Raisin gives accounts of both massive and schistose crystalline rocks, and also of sedimentary rocks. The massive crystallines occur around Murrat and Jebel Raft, and these two areas are separated by the southern mass of schists. Another area of massive crystallines is formed beyond these schists, extending to the head of Wady Allaki. The crystalline rocks described include gneiss, hornblendite, gabbro, diabase, quartz-diorite, granite, felsite, certain schists, and sediments. None of the igneous rocks can be stated with certainty to have originated as a lava-flow. Many of them have undergone much alteration since their consolidation, and the results of this are described. There is clear evidence in many cases of erosion by mud and desert-sand and the formation of a weathered coating. The crystalline schists do not present a very modern facies, and might be late Archæan or early Palæozoic. The massive crystallines may belong to different epochs.

Miss Aston gives two tables, one of which shows the actual amounts of substances found in the wells of Murrat, Bir Tilat Abda, and Bir-Ab-Anaga, whilst the second shows their approximate constitution.

CORRESPONDENCE.

FOREIGN BOULDERS IN THE CHALK.

Sir,—Mr. Martin in your last number suggests that the granite boulders from the chalk-pit at Betchworth, described by Mr. Stebbing, may have come from the south-west. Permit me to say that I know the granites of this part of England, especially that of Hey Tor, fairly well, and for reasons which I think will be obvious to any petrologist who reads my description, consider this place of origin most improbable. Before publishing his speculation Mr. Martin would have done well also to consider the following

matters: (1) the height to which the mountains must have risen (supposing the mean temperature to have been the same as now) in order that they could have generated glaciers which would have come down to the sea; (2) whether in this case it is probable that granite would have been exposed at the surface; (3) whether it is probable (looking especially at the evidence of the breccias in the red rocks of Devon) that high mountains existed in this part of England during Cretaceous times. I may add that Mr. Stebbing, so far as I remember his excellent paper, never invoked a Glacial Epoch; that spectre was raised during the debate; nor is it necessary to create a glacier to transport the boulders. Shore-ice, such as forms in the estuary of the St. Lawrence, would be quite adequate for the work. If it started from some northern locality it might readily float down (as slab-ice still does in the Atlantic) well south of the latitude of London. T. G. Bonney.

FOREIGN BOULDERS IN THE CHALK, AND GASES ENCLOSED IN CRYSTALLINE ROCKS.

Sir,—(1) Referring to Mr. G. A. Martin's interesting suggestion (Geol. Mag., April, 1897, p. 169) that the Betchworth boulder came from Dartmoor, and to its alleged similarity to the granites of Hey Tor and Lustleigh Cleave, the microscope would probably answer this question decisively. Within fifty miles of Hey Tor the floor of the English Channel is strewn with detached blocks of crystalline rocks. Of these blocks I have a large collection of slides, and also a considerable number of specimens from all parts of Dartmoor; collected for the most part by myself, or sent me by the late Mr. R. N. Worth. Not a single specimen of the Channel blocks can be referred to Dartmoor. The minute characters of the Hey Tor and Lustleigh Cleave granites are well marked both positively and negatively. Three of each class of differences will probably suffice—e.g.: presence of fibrous tourmaline; of chloride inclusions in the quartzes; of soda felspar in the large potash felspars;—absence of hornblende; of dislocation of minerals; of any approach to gneissoid structure. Besides these there are others, but most granites not derived from Dartmoor will fail to meet one or other of the above tests.

(2) In the current number of the Geological Magazine (p. 177) Dr. Tilden's paper on Gases enclosed in Crystalline Rocks is shortly reviewed, and mention is made of hydrogen in the Peterhead granite. On seeing this I referred to some notes made in 1890 on a collection of granites which Mr. Teall had kindly lent me to study. Among these notes occur the following, under the heading "Pink Granite of Rubislaw":—"A plane of fracture with fluid inclusions across another with only gas inclusions—order of sequence not made out. Rhombic negatives with bubbles. One negative hexagon with very active bubble. One patch of quartz full of hair-like inclusions and lines of bubbles: in one or two cases the hairs crossing the lines were distinctly divided in two, as seen with $\frac{1}{16}$. Could find no decided cubic crystal; any sort of crystal (in fluid inclusions) extremely rare. Bending in dark micas." Now it is not too much to

say that the above granite is as distinct from the West Country granites as any two species can be. Now for the first time we learn that the Peterhead granite was consolidated in the presence of compressed hydrogen, just as we know that the Dartmoor rock crystallized out of fluids charged with salts. The conditions were different and the minute results are different—very. Those intersecting planes of fracture are significant enough. The Rubislaw granite was consolidated; then cracked and recemented; then cracked again and recemented; and the cements varied in the two cases. In the one, the cementing silica was charged with gas, in the other not apparently so. These facts are patent to anyone who will take adequate pains to see them. The explanations must be left to experts.

A. R. Hunt.

April 9, 1897.

OBITUARY.

PROFESSOR EDWARD DRINKER COPE, A.M.,

FOR. CORR. GEOL. SOC. AND ZOOL. SOC. LOND.

Born July 28, 1840. Died April 12, 1897.

It is with deep regret that we record the death of Professor E. D. Cope, the eminent palæontologist and comparative anatomist, late of 2100, Pine Street, Philadelphia, Pa., U.S.A. E. D. Cope, who was born at Philadelphia, July 28, 1840, studied in the University of Pennsylvania and worked at anatomy in Europe (in 1863–4). For the three succeeding years (1864–7) he filled the Chair of Professor of Natural Science in Haverford College, Philadelphia, and was for some years Curator and Corresponding Secretary of the Academy of Natural Sciences in that city. At the time of his death he held the Chair of Geology and Palæontology in the University of Pennsylvania. From 1871–7, he carried on explorations in the Cretaceous strata of Kansas; the Eocene of Wyoming; the Tertiary beds of Colorado. He also served on the U.S. Geological Survey in 1874 in New Mexico; in North Montana in 1875; in Oregon and Texas in 1877.

He has accumulated a collection of over 1000 species of extinct Vertebrata, and has made known at least 600 species new to science. Professor Cope was a voluminous writer, and his papers are published in the Proceedings of the scientific Societies of Philadelphia, and in the Reports of the U.S. Geological Survey of the Territories under Dr. F. V. Hayden and Captain Wheeler. Professor Cope was an advanced Evolutionist, and his contributions on this subject have been very numerous. He was the senior Editor of the "American Naturalist," a monthly journal which contains many of his original essays. He was a Foreign Correspondent of the Zoological and Geological Societies of London, and received the Bigsby Gold Medal in 1879 from the latter Society, in recognition of the genius and skill with which he had enriched the sciences of Comparative Anatomy and Palæontology, and the immense and varied work which he had achieved among the fossil Vertebrata.